This document is scheduled to be published in the Federal Register on 07/14/2022 and available online at **federalregister.gov/d/2022-14687**, and on **govinfo.gov**

DEPARTMENT OF ENERGY

10 CFR Part 430

[EERE-2019-BT-TP-0032]

RIN 1904-AE77

Energy Conservation Program: Test Procedure for Consumer Water Heaters and Residential-Duty Commercial Water Heaters

AGENCY: Office of Energy Efficiency and Renewable Energy, Department of Energy.

ACTION: Supplemental notice of proposed rulemaking and request for comment.

SUMMARY: The U.S. Department of Energy ("DOE") is publishing this supplemental notice of proposed rulemaking ("SNOPR") to amend the test procedure for consumer water heaters and residential-duty commercial water heaters. This SNOPR updates the proposals presented in a notice of proposed rulemaking published in the *Federal Register* on January 11, 2022. In this SNOPR, DOE proposes additional amendments that would provide additional specificity regarding flow rate tolerances for water heaters with a rated storage volume of less than 2 gallons; allow for voluntary representations at certain additionally specified test conditions for heat pump water heaters; revise the proposed specifications regarding separate storage tank requirements for certain types of water heaters; provide instructions for testing certain water heaters that store water at a temperature higher than the delivery setpoint; establish a metric and method for determining the effective storage volume of certain storage-type water heaters; and update the proposed methodology for estimating the internal tank temperature of water heaters

which cannot be directly measured. DOE is seeking comment from interested parties on these proposals.

DATES: DOE will accept comments, data, and information regarding this SNOPR no later than **[INSERT DATE 21 DAYS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER*]**. See section IV, "Public Participation," for details.

ADDRESSES: *Comments*: Interested persons are encouraged to submit comments using the Federal eRulemaking Portal at *www.regulations.gov*, under docket number EERE-2019-BT-TP-0032. Follow the instructions for submitting comments. Alternatively, interested persons may submit comments, identified by docket number EERE-2019-BT-TP-0032 and/or RIN 1904-AE77, by any of the following methods:

(1) *E-mail: WaterHeaters2019TP0032@ee.doe.gov*. Include docket number EERE-2019-BT-TP-0032 in the subject line of the message.

(2) *Postal Mail:* Appliance and Equipment Standards Program, U.S. Department of Energy, Building Technologies Office, Mailstop EE-5B, 1000 Independence Avenue, SW., Washington, DC, 20585-0121. Telephone: (202) 287-1445. If possible, please submit all items on a compact disc ("CD"), in which case it is not necessary to include printed copies.

(3) *Hand Delivery/Courier:* Appliance and Equipment Standards Program, U.S. Department of Energy, Building Technologies Office, 950 L'Enfant Plaza, SW., 6th Floor, Washington, DC, 20024. Telephone: (202) 287-1445. If possible, please submit all items on a CD, in which case it is not necessary to include printed copies.

No telefacsimiles ("faxes") will be accepted. For detailed instructions on submitting comments and additional information on this process, see section V of this document (Public Participation).

Docket: The docket for this activity, which includes *Federal Register* notices, public meeting/webinar attendee lists and transcripts, comments, and other supporting documents/materials, is available for review at *www.regulations.gov*. All documents in the docket are listed in the *www.regulations.gov* index. However, not all documents listed in the index may be publicly available, such as information that is exempt from public disclosure.

The docket webpage can be found at *www.regulations.gov/docket?D=EERE-2019-BT-TP-0032*. The docket webpage contains instructions on how to access all documents, including public comments, in the docket. See section V (Public Participation) for information on how to submit comments through *www.regulations.gov*.

FOR FURTHER INFORMATION CONTACT: Ms. Julia Hegarty, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Office, EE-5B, 1000 Independence Avenue, SW., Washington, DC, 20585-0121. Telephone: (202) 597-6737. E-mail: *ApplianceStandardsQuestions@ee.doe.gov*.

Mr. Eric Stas, U.S. Department of Energy, Office of the General Counsel, GC-33, 1000 Independence Avenue, SW., Washington, DC, 20585-0121. Telephone: (202) 586-5827. E-mail: *Eric.Stas@hq.doe.gov*.

For further information on how to submit a comment, review other public comments and the docket, contact the Appliance and Equipment Standards Program staff at (202) 287-1445 or by e-mail: *ApplianceStandardsQuestions@ee.doe.gov*.

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I. Authority and Background

Consumer water heaters are included in the list of "covered products" for which DOE is authorized to establish and amend energy conservation standards and test procedures. (42 U.S.C. 6292(a)(4)) DOE's energy conservation standards and test procedures for consumer water

heaters are currently prescribed respectively at Title 10 of the Code of Federal Regulations ("CFR"), part 430 section 32(d), and 10 CFR part 430, subpart B, appendix E ("appendix E"), *Uniform Test Method for Measuring the Energy Consumption of Water Heaters*. Residential-duty commercial water heaters, for which DOE is also authorized to establish and amend energy conservation standards and test procedures (42 U.S.C. 6311(1)(K)), must also be tested according to appendix E. 10 CFR 431.106(b)(1) (*See* 42 U.S.C. 6295(e)(5)(H)). DOE's energy conservation standards for residential-duty commercial water heaters are currently prescribed at 10 CFR 431.110(b)(1). The following sections discuss DOE's authority to establish and amend test procedures for consumer water heaters and residential-duty commercial water heaters, as well as relevant background information regarding DOE's consideration of test procedures for these products and equipment.

A. Authority

The Energy Policy and Conservation Act, as amended ("EPCA"),[1] authorizes DOE to regulate the energy efficiency of a number of consumer products and certain industrial equipment. (42 U.S.C. 6291–6317, as codified) Title III, Part B[2] of EPCA established the Energy Conservation Program for Consumer Products Other Than Automobiles, which sets forth a variety of provisions designed to improve energy efficiency. (42 U.S.C. 6291-6309, as codified) These products include consumer water heaters, one of the subjects of this document. (42 U.S.C. 6292(a)(4)) Title III, Part C[3] of EPCA, added by Pub. L. 95-619, Title IV, section 441(a), established the Energy Conservation Program for Certain Industrial Equipment, which again sets forth a variety of provisions designed to improve energy efficiency. (42 U.S.C. 6311-

[1] All references to EPCA in this document refer to the statute as amended through Energy Act of 2020, Pub. L. 116-260 (Dec. 27, 2020), which reflect the last statutory amendments that impact Parts A and A-1 of EPCA.
[2] For editorial reasons, upon codification in the U.S. Code, Part B was redesignated Part A.
[3] For editorial reasons, upon codification in the U.S. Code, Part C was redesignated Part A-1.

6317, as codified) This equipment includes residential-duty commercial water heaters, which are also the subject of this document. (42 U.S.C. 6311(1)(k))

The energy conservation program under EPCA consists essentially of four parts: (1) testing, (2) labeling, (3) Federal energy conservation standards, and (4) certification and enforcement procedures. Relevant provisions of EPCA specifically include definitions (42 U.S.C. 6291; 42 U.S.C. 6311), test procedures (42 U.S.C. 6293; 42 U.S.C. 6314), labeling provisions (42 U.S.C. 6294; 42 U.S.C. 6315), energy conservation standards (42 U.S.C. 6295; 42 U.S.C. 6313), and the authority to require information and reports from manufacturers (42 U.S.C. 6296; 42 U.S.C. 6316).

The Federal testing requirements consist of test procedures that manufacturers of covered products and commercial equipment must use as the basis for: (1) certifying to DOE that their products/equipment comply with the applicable energy conservation standards adopted pursuant to EPCA (42 U.S.C. 6295(s); 42 U.S.C. 6296; 42 U.S.C. 6316(a)-(b)), and (2) making other representations about the efficiency of those consumer products (42 U.S.C. 6293(c); 42 U.S.C. 6314(d)). Similarly, DOE must use these test procedures to determine whether the products comply with relevant standards promulgated under EPCA. (42 U.S.C. 6295(s))

Federal energy efficiency requirements for covered products and equipment established under EPCA generally supersede State laws and regulations concerning energy conservation testing, labeling, and standards. (42 U.S.C. 6297(a)-(c); 42 U.S.C. 6316(a)-(b)) DOE may, however, grant waivers of Federal preemption in limited circumstances for particular State laws or regulations, in accordance with the procedures and other provisions of EPCA. (42 U.S.C. 6297(d); 42 U.S.C. 6316(a); 42 U.S.C. 6316(b)(2)(D))

Under 42 U.S.C. 6293, EPCA sets forth the criteria and procedures DOE must follow when prescribing or amending test procedures for covered products. Specifically, EPCA requires that any test procedures prescribed or amended shall be reasonably designed to produce test results which measure energy efficiency, energy use, or estimated annual operating cost of a covered product during a representative average use cycle or period of use and not be unduly burdensome to conduct. (42 U.S.C. 6293(b)(3)) Under 42 U.S.C. 6314, the statute sets forth the criteria and procedures DOE must follow when prescribing or amending test procedures for covered equipment, reciting similar requirements at 42 U.S.C. 6314(a)(2).

In addition, the Energy Independence and Security Act of 2007 (EISA 2007) amended EPCA to require that DOE amend its test procedures for all covered consumer products to integrate measures of standby mode and off mode energy consumption. (42 U.S.C. 6295(gg)(2)(A)) Standby mode and off mode energy consumption must be incorporated into the overall energy efficiency, energy consumption, or other energy descriptor for each covered product unless the current test procedures already account for and incorporate standby and off mode energy consumption or such integration is technically infeasible. (42 U.S.C. 6295(gg)(2)(A)(i)–(ii)) If an integrated test procedure is technically infeasible, DOE must prescribe a separate standby mode and off mode energy use test procedure for the covered product, if technically feasible. (42 U.S.C. 6295(gg)(2)(A)(ii)) Any such amendment must consider the most current versions of the International Electrotechnical Commission (IEC) Standard 62301[4] and IEC Standard 62087,[5] as applicable. (42 U.S.C. 6295(gg)(2)(A))

The American Energy Manufacturing Technical Corrections Act (AEMTCA), Pub. L. 112–210, further amended EPCA to require that DOE establish a uniform efficiency descriptor

[4] IEC 62301, *Household electrical appliances—Measurement of standby power* (Edition 2.0, 2011–01).
[5] IEC 62087, *Methods of measurement for the power consumption of audio, video, and related equipment* (Edition 3.0, 2011–04).

and accompanying test methods to replace the energy factor (EF) metric for covered consumer water heaters and the thermal efficiency (TE) and standby loss (SL) metrics for commercial water-heating equipment[6] within one year of the enactment of AEMTCA. (42 U.S.C. 6295(e)(5)(B)–(C)) The uniform efficiency descriptor and accompanying test method were required to apply, to the maximum extent practicable, to all water-heating technologies in use at the time and to future water-heating technologies, but could exclude specific categories of covered water heaters that do not have residential uses, can be clearly described, and are effectively rated using the TE and SL descriptors. (42 U.S.C. 6295(e)(5)(F) and (H)) In addition, beginning one year after the date of publication of DOE's final rule establishing the uniform descriptor, the efficiency standards for covered water heaters were required to be denominated according to the uniform efficiency descriptor established in the final rule (42 U.S.C. 6295(e)(5)(D)); and for affected covered water heaters tested prior to the effective date of the test procedure final rule, DOE was required to develop a mathematical factor for converting the measurement of their energy efficiency from the EF, TE, and SL metrics to the new uniform energy descriptor. (42 U.S.C. 6295(e)(5)(E)(i)–(ii))

EPCA also requires that, at least once every 7 years, DOE evaluate test procedures for each type of covered product or equipment, including consumer water heaters and residential-duty commercial water heaters, to determine whether amended test procedures would more accurately or fully comply with the requirements for the test procedures to not be unduly burdensome to conduct and be reasonably designed to produce test results that reflect energy

[6] The initial thermal efficiency and standby loss test procedures for commercial water heating equipment (including residential-duty commercial water heaters) were added to EPCA by the Energy Policy Act of 1992 (EPACT 1992), Pub. L. 102–486, and corresponded to those referenced in the ASHRAE and Illuminating Engineering Society of North America (IESNA) Standard 90.1–1989 (*i.e.,* ASHRAE Standard 90.1–1989). (42 U.S.C. 6314(a)(4)(A)) DOE subsequently updated the commercial water heating equipment test procedures on two separate occasions—once in a direct final rule published on October 21, 2004, and again in a final rule published on May 16, 2012. These rules incorporated by reference certain sections of the latest versions of American National Standards Institute (ANSI) Standard Z21.10.3, *Gas Water Heaters, Volume III, Storage Water Heaters with Input Ratings Above 75,000 Btu Per Hour, Circulating and Instantaneous,* available at the time (*i.e.,* ANSI Z21.10.3–1998 and ANSI Z21.10.3–2011, respectively). 69 FR 61974, 61983 (Oct. 21, 2004) and 77 FR 28928, 28996 (May 16, 2012).

efficiency, energy use, and estimated operating costs during a representative average use cycle (or, additionally, period of use for consumer products). (42 U.S.C. 6293(b)(1)(A); 42 U.S.C. 6314(a)(1)(A))

If the Secretary determines, on her own behalf or in response to a petition by any interested person, that a test procedure should be prescribed or amended, the Secretary shall promptly publish in the *Federal Register* proposed test procedures and afford interested persons an opportunity to present oral and written data, views, and arguments with respect to such procedures. (42 U.S.C. 6293(b)(2); 42 U.S.C. 6314(b)) The comment period on a proposed rule to amend a test procedure shall be at least 60 days[7] and may not exceed 270 days. (42 U.S.C. 6293(b)(2)) In prescribing or amending a test procedure, the Secretary shall take into account such information as the Secretary determines relevant to such procedure, including technological developments relating to energy use or energy efficiency of the type (or class) of covered products involved. (42 U.S.C. 6293(b)(2)) If DOE determines that test procedure revisions are not appropriate, DOE must publish in the *Federal Register* its determination not to amend the test procedures. (42 U.S.C. 6293(b)(1)(A)(ii) and 42 U.S.C. 6314(a)(1)(A)(ii))

DOE is conducting this rulemaking in satisfaction of the 7-year-lookback review requirement specified in EPCA. (42 U.S.C. 6293(b)(1)(A) and 42 U.S.C. 6314(a)(1)(A))

[7] For covered, equipment, if the Secretary determines that a test procedure amendment is warranted, the Secretary must publish proposed test procedures in the *Federal Register*, and afford interested persons an opportunity (of not less than 45 days' duration) to present oral and written data, views, and arguments on the proposed test procedures. (42 U.S.C. 6314(b))

B. Background

On January 11, 2022, DOE published in the *Federal Register* a notice of proposed rulemaking ("January 2022 NOPR") in which the Department proposed to update appendix E, and related sections of the CFR, as follows:

(1) Incorporate by reference current versions of industry standards referenced by the current and proposed DOE test procedures: American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 41.1[8], ASHRAE Standard 41.6[9], the pending update to ASHRAE Standard 118.2[10] (contingent on it being substantively the same as the draft which was under review), ASTM International (ASTM) D2156[11], and ASTM E97.[12]

(2) Add definitions for "circulating water heater," "low temperature water heater," and "tabletop water heater."

(3) Specify how a mixing valve should be installed when the water heater is designed to operate with one.

(4) Modify flow rate requirements during the FHR test for water heaters with a rated storage volume less than 20 gallons.

[8] ASHRAE Standard 41.1-2020, "Standard Methods for Temperature Measurement," approved June 30, 2020.
[9] ASHRAE Standard 41.6-2014, "Standard Method for Humidity Measurement," ANSI approved July 3, 2014.
[10] ASHRAE Standard 118.2-2022, "Method of Testing for Rating Residential Water Heaters and Residential-Duty Commercial Water Heaters," ANSI approved March 1, 2022.
[11] ASTM Standard D2156-09 (RA 2018), "Standard Test Method for Smoke Density in Flue Gases from Burning Distillate Fuels," reapproved October 1, 2018.
[12] ASTM Standard E97-1987 (W 1991), "Standard Test Methods for Directional Reflectance Factor, 45-Deg 0-Deg, of Opaque Specimens by Broad-Band Filter Reflectometry," approved January 1987, withdrawn 1991. Referenced by ASTM Standard D2156-09 (RA 2018).

(5) Modify timing of the first measurement in each draw of the 24-hour simulated-use test.

(6) Clarify the determination of the first recovery period.

(7) Clarify the mass of water to be used to calculate recovery efficiency.

(8) Modify the terminology throughout appendix E to explicitly state “non-flow activated” and “flow-activated” water heater, where appropriate.

(9) Clarify the descriptions of defined measured values for the standby period measurements.

(10) Modify the test condition specifications and tolerances, including electric supply voltage tolerance, ambient temperature, ambient dry bulb temperature, ambient relative humidity, standard temperature and pressure definition, gas supply pressure, and manifold pressure.

(11) Add provisions to address gas-fired water heaters with measured fuel input rates that deviate from the certified input rate.

(12) Clarify provisions for calculating the volume or mass delivered.

(13) Add specifications for testing for the newly defined “low temperature water heaters.”

(14) Clarify testing requirements for the heat pump part of a split-system heat pump water heater.

(15) Define the use of a separate unfired hot water storage tank for testing water heaters designed to operate with a separately sold hot water storage tank.

(16) Clarify that any connection to an external network or control be disconnected during testing.

(17) Add procedures for estimating internal stored water temperature for water heater designs in which the internal tank temperature cannot be directly measured.

(18) Modify the provisions for untested water heater basic models within 10 CFR 429.70(g) to include electric instantaneous water heaters.

87 FR 1554, 1558.[13]

DOE received written comments in response to the January 2022 NOPR pertinent to the issues discussed in this SNOPR from the interested parties listed in Table III.1 of this document. In this SNOPR, DOE is maintaining the proposals from the January 2022 NOPR with modifications as discussed in this SNOPR and will address comments on any remaining topics in a future test procedure final rule.

Table III.1 List of Commenters with Written Submissions in Response to the January 2022 NOPR Relevant to Topics Covered in this SNOPR

Commenter(s)	Reference in this SNOPR	Comment No. in Docket	Commenter Type
A.O. Smith Corporation	A.O. Smith	37	Manufacturer

[13] A correction was published in the *Federal Register* on January 19, 2022, to properly reflect the date of the public meeting to discuss the test procedure NOPR. 87 FR 2731.

Air Conditioning, Heating, and Refrigeration Institute	AHRI	40	Trade Association
Appliance Standards Awareness Project, American Council for and Energy-Efficient Economy, National Consumer Law Center	Joint Advocates	34	Efficiency Advocacy Organizations
Bradford White Corporation	BWC	33	Manufacturer
Pacific Gas and Electric Company, San Diego Gas and Electric, and Southern California Edison; collectively, the California Investor-Owned Utilities	CA IOUs	36	Utilities
Jim Lutz	Lutz	35	Individual
New York State Energy Research and Development Authority	NYSERDA	32	State Agency
Northwest Energy Efficiency Alliance	NEEA	30	Efficiency Advocacy Organization
Rheem Manufacturing Company	Rheem	31	Manufacturer

As discussed, this SNOPR addresses only those comments related to the proposals laid out in this document; all other relevant comments will be addressed in a future stage of the rulemaking. A parenthetical reference at the end of a comment quotation or paraphrase provides the location of the item in the public record.[14]

II. Synopsis of Proposed Amendments

DOE's proposed actions in this SNOPR are summarized in Table II.1 of this document as compared to the January 2022 TP NOPR. Reasons for each proposed change are also explained in summary.

Table II.1 Summary of Proposed Changes Addressed in this SNOPR

January 2022 NOPR Proposal	SNOPR	Attribution
Proposed that flow rates for all water heaters with rated storage volume less than 2 gallons must be maintained within a tolerance of ±0.25 gallons per minute.	Additionally proposes that for water heaters with rated storage volume less than 2 gallons and a rated Max GPM of less than 1 gallon per minute, the flow rate tolerance shall be ±25 percent of the rated Max GPM.	Improve repeatability and reproducibility of the test procedure.

[14] The parenthetical reference provides a reference for information located in the docket of DOE's rulemaking to develop test procedures for consumer water heaters and residential-duty commercial water heaters. (Docket No. EERE-2019-BT-TP-0032, which is maintained at *www.regulations.gov*). The references are arranged as follows: (commenter name, comment docket ID number, page of that document).

Did not propose to allow for optional efficiency representations at alternative test conditions for heat pump water heaters.	Proposes to allow for optional efficiency representations at alternative test conditions for heat pump water heaters.	Harmonize with current industry testing practices.
Did not propose a definition for split-system heat pump water heaters.	Proposes a definition for split-system heat pump water heaters to distinguish these from heat pump-only water heaters.	Provide additional clarity to application of test conditions for heat pump water heaters.
Proposed to define "circulating water heaters" and require that such products be tested using an 80 gallon (± 1 gallon) unfired hot water storage tank ("UFHWST") that meets the energy conservation standards for an unfired hot water storage tank at 10 CFR 431.110(a).	Proposes that gas-fired circulating water heaters be tested using a UFHWST with a storage volume between 80 and 120 gallons and an R-value exactly at the minimum R-value required at 10 CFR 431.110(a), and that heat pump circulating water heaters be tested using a 40-gallon electric resistance water heater at the minimum UEF standard required at 10 CFR 430.32(d).	Improve representativeness of test methodology for circulating water heaters.
Proposed to continue to specify that water heaters with multiple modes of operation be tested in the "default" or other similarly named mode as currently required by Appendix E.	Proposes that water heaters (with the exception of demand-response water heaters) with user-selectable modes to "over-heat" the water stored in the tank to increase effective capacity be tested at the highest internal tank temperature that can be achieved while maintaining the outlet water temperature at 125 ± 5 °F. If no such over-heated mode exists, the unit is to be tested in a default mode.	Improve representativeness of test methodology for water heaters with user-selectable overheated storage tank modes.
Did not include a definition for "demand-response water heater."	Proposes to define "demand-response water heater" based on the ENERGY STAR specification v5.0 definition for connected water heating product, with the additional requirement that demand-response water heaters cannot over-heat as a result of user-initiated operation.	Clarify the test methods for products with demand-response utility,
Did not include any proposal related to the effective storage volume of storage-type water heaters.	Proposes to establish a metric and method for determining the effective storage volume of storage-type water heaters.	Adopt a metric to provide additional information to consumers on product performance.
Proposed a method of determining the internal storage tank temperature (for water heaters with rated storage volume greater than or equal to 2 gallons which cannot be directly measured) based on an assumption that the mean tank temperature is approximately the average of the inlet water temperature and the outlet water temperature.	Proposes a method of determining the internal storage tank temperature using draws at the beginning and end of the 24-hour simulated use test.	Adopt a test method for certain water heaters which cannot be directly measured.

III. Discussion

A. Flow Rate Tolerance Requirements

In this SNOPR, DOE proposes to supplement the proposal presented in the January 2022 NOPR regarding specified flow rate tolerances for water heaters with a rated storage volume under 2 gallons.

Section 5.4 of appendix E provides instructions for conducting the 24-hour simulated-use test for the determination of the uniform energy factor ("UEF"). Section 5.4.1 of appendix E specifies directions for determination of the draw pattern of the water heater under test; section 5.4.2 of appendix E specifies the test sequence for water heaters with rated storage volume greater than or equal to 2 gallons; and section 5.4.3 of appendix E specifies the test sequence for water heaters with rated storage volume less than 2 gallons. These test sequences specify the timings of each water draw during the 24-hour simulated-use test, the flow rates at which the draws must occur, and condition tolerances for these draws.

In particular, section 5.4.2 of appendix E, *Test Sequence for Water Heaters with Rated Storage Volumes Greater Than or Equal to 2 Gallons*, provides that all draws during the 24-hour simulated-use test must be made at the flow rates specified in the applicable draw pattern table in section 5.5 of this appendix, within a tolerance of ±0.25 gallons per minute (±0.9 liters per minute). Section 5.4.3 of appendix E, *Test Sequence for Water Heaters with Rated Storage Volume Less Than 2 Gallons*, currently does not provide explicit instruction for the tolerance on the flow rate.

Within the proposed amendments to the regulatory text provided in the January 2022 NOPR, DOE included a proposed amendment to section 5.4.3 of appendix E to specify that flow rates for water heaters with rated storage volume less than 2 gallons must be maintained within a

tolerance of ±0.25 gallons per minute. 87 FR 1554, 1603 (Jan. 11, 2022). The preamble to the January 2022 NOPR did not include discussion of this topic, nor did DOE specifically request for comment on this topic.

Adopting these proposed tolerances at section 5.4.3 of appendix E would ensure repeatability and reproducibility of test results for water heaters with rated storage volume less than 2 gallons. Most water heaters with storage volume less than 2 gallons are flow-activated devices, meaning that burner or heating element activation is controlled based on sensing the flow rate when hot water is called for. As such, significant variations in the flow rate from test to test could affect the measured efficiency of these products.

In this SNOPR, DOE is updating its proposal to include additional specificity for water heaters with flow rates less than 1 gallon per minute. In section III.C.6 of the January 2022 NOPR, DOE discussed water heaters on the market with maximum gallon per minute ("Max GPM") delivery capacities below 1 gallon per minute. 87 FR 1554, 1582 (Jan. 11, 2022). For these models, the "very small" draw pattern for the 24-hour simulated-use test would be applicable. Section 5.5 of appendix E states that, for the very small draw pattern, if the water heater has a Max GPM rating less than 1 gallon per minute (3.8 L/min), then all draws shall be implemented at a flow rate equal to the rated Max GPM. For products with Max GPM less than 1 gallon per minute, an allowable flow rate tolerance of ±0.25 gallon per minute would represent a significant variation of flow rate in comparison to the rated Max GPM. For example, for a water heater with Max GPM of 0.5 gallon per minute, a tolerance of ±0.25 gallon per minute would represent a ±50 percent difference from the rated flow rate. Furthermore, in its review of publicly certified water heater ratings,[15] DOE identified models with rated Max GPM delivery

[15] DOE consulted its public Certification Compliance Database (Available at: *www.regulations.doe.gov/certification-data/CCMS-4-Water_Heaters.html#q=Product_Group_s%3A%22Water%20Heaters%22*).

capacities as low as 0.20 gallon per minute. For such products, a flow rate tolerance of ±0.25 gallon per minute would allow for either flow rates close to zero or flow rates that are more than twice the rated Max GPM; either case would lead to results unrepresentative of actual product usage. Therefore, in this SNOPR, DOE proposes further amending section 5.4.3 of appendix E to specify that for water heaters with a rated Max GPM of less than 1 gallon per minute, the flow rate tolerance shall be ±25 percent of the rated Max GPM. For such products, a flow rate tolerance of ±25 percent would represent the same level of variation (on a percentage basis) as for products rated at 1.0 gallon per minute and subject to a tolerance of ±0.25 gallon per minute.

By way of example, under the proposal, for a water heater with a rated Max GPM flow rate of 0.5 gallon per minute, the required tolerance would be ±0.125 gallon per minute. For a water heater with a rated Max GPM flow rate of 0.20 gallon per minute, the required tolerance would thus be ±0.05 gallon per minute.

As discussed, EPCA requires that test procedures be reasonably designed to produce test results which measure energy efficiency, energy use, or estimated annual operating cost of a covered product during a representative average use cycle or period of use and not be unduly burdensome to conduct. (42 U.S.C. 6293(b)(3)) DOE expects that laboratories may require high-precision water flow rate instrumentation (*e.g.*, Coriolis flow meters) in order to maintain the tolerances discussed, in particular for water heaters with rated Max GPM flow rates less than 1 gallon per minute. DOE is aware through its testing activities that multiple third-party laboratories already use Coriolis flow meters. In reviewing water heater test data previously collected, DOE has observed third-party laboratories maintaining flow rate condition tolerances as low as ±0.05 gallon per minute. For these reasons, DOE has initially determined that the proposed tolerances would generally not require additional capital investments for test laboratories and, therefore, would not be unduly burdensome to conduct.

DOE also has tentatively determined that the proposed amendment would not alter the measured efficiency of consumer water heaters and residential-duty commercial water heaters, nor require retesting or recertification solely as a result of DOE's adoption of the proposed amendments to the test procedure, if made final. In the absence of an explicit instruction for the flow rate tolerance applicable to water heaters with rated storage volume under 2 gallons, DOE expects that general industry best practice is to apply the flow rate tolerances being proposed for section 5.4.3 of appendix E for water heaters with rated storage volume less than 2 gallons (based on DOE's review of third-party laboratory test data), such that this proposal is expected to be consistent with current methodology.

With the addition of these proposed amendments to section 5.4.3 of appendix E, DOE maintains the proposals set forth in the January 2022 NOPR.

DOE seeks comment on the proposed amendment to specify flow rate tolerances for the 24-hour simulated use test for water heaters with rated storage volume under 2 gallons, and in particular to specify the tolerance as ±25 percent for water heaters with a rated maximum flow rate of less than 1 gallon per minute. DOE is particularly interested in test data or information that would indicate the technical feasibility of maintaining the tolerances proposed with instrumentation that is used in general practice, as well as the potential impacts on test burden.

B. Optional Test Conditions

Section 2.2 of appendix E specifies that the ambient air temperature shall be maintained between 65.0 °F and 70.0 °F (18.3 °C and 21.1 °C) on a continuous basis during the test. Additionally, for heat pump water heaters, that test procedure provision provides that the dry-

bulb temperature shall be maintained at 67.5 °F ±1 °F (19.7 °C ±0.6 °C) and that the relative humidity shall be maintained at 50 percent ±2 percent throughout the test.[16]

In the January 2022 NOPR, DOE discussed comments previously received on the April 2020 RFI suggesting that DOE explore the usage of NEEA's Advanced Water Heating Specification for voluntary climate-specific efficiency representations of heat pump water heaters. 87 FR 1554, 1580 (Jan. 11, 2022). In response to those comments, DOE stated that it did not have data to indicate what conditions would be representative for regional representations, and, thus, DOE tentatively decided not to allow optional representations of additional efficiency ratings at test conditions other than those found in the DOE test procedure, such as those made in accordance with NEEA's Advanced Water Heating Specification. *Id*.

In response to the January 2022 NOPR, DOE received additional comments regarding optional representations that have led the Department to reconsider its tentative decision not to allow optional representations.

The CA IOUs stated that water heater installation practices vary regionally, and that similar units installed in the same region can experience different ambient conditions. The CA IOUs further stated that the direct relationship between the diverse ambient conditions and efficiency make it impossible to choose a single representative value for ambient conditions for the consumer water heaters test procedure that will yield useful energy consumption estimates for heat pump water heaters. The CA IOUs asserted that in the case of a split-system heat pump water heater, the condenser is almost always located in an unconditioned space (*e.g.,* outdoors), such that the ambient conditions specified in the current DOE test procedure are not representative. The CA IOUs recommended that DOE clarify whether manufacturers may

[16] DOE proposed amendments to the ambient air tolerance requirements in the January 2022 NOPR. 87 FR 1554, 1577-1578 (Jan. 11, 2022).

provide information on the performance of heat pump water heaters at ambient temperatures other than 67.5 °F ±1 °F. The CA IOUs reiterated their recommendation to allow manufacturers to provide representations for more than one ambient condition, stating that allowing manufacturers to state performance under different conditions would allow them to introduce heat pump water heater models optimized for different applications, would help keep performance claims consistent, and would help consumers select the most appropriate products. (CA IOUs, No. 36 at p. 2)

The Joint Advocates stated that the value of having test data at both colder and warmer conditions than those specified in the current test procedure is that they would allow for calculating UEFs for any climate regardless of whether the specific optional test conditions are representative of any region. The Joint Advocates reiterated its recommendation that DOE allow voluntary reporting of ratings at two additional test conditions. The Joint Advocates asserted that allowing optional reporting would help provide a better understanding of the differences in heat pump water heater performance at various conditions without increasing test burden for manufacturers who do not wish to report these additional rating. (Joint Advocates, No. 34 at p. 1)

NYSERDA requested that DOE require heat pump water heater performance data at a range of operating conditions. NYSERDA stated that demonstrating performance at different ambient temperatures is a commonly applied approach for heat pumps that serve HVAC loads, and that similar treatment for heat pump water heaters is appropriate. NYSERDA stated that in order for heat pump water heaters to provide utility in all climates, including the colder temperatures in New York, consumers and installers will need to understand the expected performance at a range of operating conditions. NYSERDA encouraged DOE to allow manufacturers to provide performance data at conditions representative of where heat pump

water heaters will be installed throughout the country. NYSERDA specifically referenced NEEA's Advanced Water Heating Specification as an example resource. (NYSERDA, No. 32 at p. 3)

BWC stated that voluntary representations would potentially increase burden and not increase representativeness for performance on a national basis. BWC expressed its support for DOE's tentative determination not to allow additional voluntary representations. (BWC, No. 33 at p. 8)

After considering these comments, the Department once again notes that EPCA requires that the DOE test procedure must be reasonably designed to produce test results which measure energy efficiency during a representative average use cycle or period of use. (42 U.S.C. 6293(b)(3)) While the test conditions in the current appendix E test procedure must remain representative for the nation as a whole, comments from interested parties have demonstrated that allowing additional representations of efficiency at alternative ambient conditions could provide consumers with additional information about the expected performance of heat pump water heaters at conditions that are representative of their specific installation circumstances. For other types of covered products and equipment, DOE has adopted optional metrics for voluntary representations where it was determined that the primary efficiency metric would not be representative for certain installation conditions common for the product or equipment. For heat pump water heaters, both the efficiency and the heating capacity of the product are sensitive to the ambient conditions, and in general will be lower at colder ambient temperatures and higher at warmer ambient temperatures. For example, at lower ambient temperatures, the reduction in heating capacity of the heat pump could result in back-up electric resistance heating elements operating more frequently than at the current DOE rating conditions. Differences in ambient conditions also would affect integrated heat pump water heaters installed in unconditioned

spaces (*e.g.*, garage or attic) and split-system heat pump water heaters for which the heat pump components are located outdoors. Depending on the installation location, the ambient conditions may vary significantly from the conditions in the DOE test method, thereby resulting in significantly different performance for such products. For these reasons, in this SNOPR, DOE has tentatively determined to allow for certain optional representations for additional ambient conditions, as described further in the following paragraphs. DOE understands this to be the intent in NYSERDA's request (however, NYSERDA's comment discusses both a requirement for optional representations as well as an allowance for optional representations). In response to BWC's concerns regarding a potential increase in test burden, DOE proposes that any testing at multiple ambient conditions would be optional, and DOE is not proposing to require testing at the alternative ambient conditions. In summary, DOE is proposing to define new metrics for optional representations based primarily upon the test conditions provided in NEEA's Advanced Water Heating Specification version 8.0 ("AWHS v8.0").

AWHS v8.0 was published by NEEA on March 1, 2022. Though early editions of the AWHS focused primarily on providing more representative performance metrics for heat pump water heaters in cold climates, the latest editions are now more broadly focused on providing representative performance metrics for heat pump water heaters across all climates. Performance metrics in the AWHS are generally calculated by measuring energy efficiency at multiple (two or more) ambient test conditions, linearly interpolating between the test results, and finally calculating an ambient temperature-weighted efficiency metric using temperature bin data. The metric is a cold climate efficiency ("CCE") rating for integrated heat pump water heaters installed in semi-conditioned (*i.e.,* garage, basement) spaces and a seasonal coefficient of performance ("SCOP") for split-system heat pump water heaters (where the heat pump is separated from the storage tank and located outdoors).

NEEA maintains a Qualified Products List for heat pump water heaters tested by manufacturers to the AWHS.[17] As of February 2022, the Qualified Products List contains CCE and SCOP representations from seventeen heat pump water heater brands. As such, DOE notes that manufacturers are already conducting testing per the AWHS and are providing representations in accordance with its test methods. On this basis, DOE has tentatively determined that adopting these test points for voluntary testing and representations would not significantly increase test burden for manufacturers who choose to provide these ratings.

In its review of the AWHS v8.0, DOE determined that there are several differences between the test conditions provided and those present in the appendix E test procedure. These differences include ambient dry bulb temperatures, relative humidity conditions, and supply water temperatures.

For integrated heat pump water heaters, AWHS v8.0 determines CCE_{50} at ambient air conditions of 50 °F dry bulb temperature and 58 percent relative humidity, with a supply water temperature of 50 °F. An additional high-temperature condition of 95 °F is also included but noted as optional in appendix B.1.1 to AWHS v8.0. DOE is proposing adopt the low ambient air conditions (50 °F and 58 percent relative humidity) and the high ambient air conditions (95 °F and 40 percent relative humidity) for optional representations of integral heat pump water heaters. Additionally, AWHS v8.0 modifies the inlet water temperatures at these ambient conditions to reflect the corresponding mains water temperature expected at each outdoor air temperature. At the 50 °F ambient condition, the specified inlet water temperature is also 50 °F, and at the 95 °F ambient condition, the specified inlet water temperature is 67 °F. Although NEEA's AWHS v8.0 specifies these air and water conditions only for integrated heat pump

[17] Available at: *neea.org/img/documents/residential-unitary-HPWH-qualified-products-list.pdf* (Last accessed on May 11, 2022).

water heaters, DOE has tentatively determined that these conditions could also be used for heat pump-only water heaters, which typically do not have any outdoor components.

For split-system heat pump water heaters, Appendix B.4 to AWHS v8.0 includes a note that the test method and calculation procedure is "in progress," and test conditions are labeled as "draft testing conditions." Appendix B.4 to AWHS v8.0 states, "broadly, the method will consist of calculating an efficiency for each test in Table 8 following the Uniform Energy Factor calculation method but substituting in appropriate temperature conditions." For split-system heat pump water heaters, AWHS v8.0 determines SCOP at ambient air conditions ranging from 5 °F dry bulb temperature and 30 percent relative humidity to 95 °F dry bulb temperature and 25 percent relative humidity. Similar to the requirements in AWHS v8.0 for integrated heat pump water heaters, the supply water temperature requirement varies with ambient dry bulb temperature. The four standard test conditions for SCOP in AWHS v8.0 are shown in Table 8 of AWHS v8.0 and in Table III.1 in this SNOPR.

Table III.1 AWHS v8.0 Standard Test Conditions for Split-System Heat Pump Water Heaters

	Outdoor Conditions			Water	Indoor Conditions	
Test Point	Outdoor Dry-Bulb Temperature	Outdoor Wet-Bulb Temperature	Relative Humidity	Supply Water Temperature	Dry-Bulb Temperature	Relative Humidity
A	5 °F	2 °F	30%	42 °F	67.5 °F	Not specified
B	34 °F	31 °F	72%	47 °F		
C	68 °F	57 °F	50%	58 °F		
D	95 °F	69 °F	25%	67 °F		

Test point C in AWHS v8.0 most closely resembles the current test condition in appendix E. In this SNOPR, DOE is proposing to adopt the three additional outdoor air conditions (A, B, and D in AWHS v8.0) for optional representations of split-system heat pump water heaters. Where indoor relative humidity is not currently specified in AWHS v8.0 for split-system heat pump water heaters, DOE is proposing to use the 50-percent relative humidity requirement from the current appendix E test procedure in order to maintain the consistency and comparability of

results. Tolerances on these conditions would be the same as those required for the standard UEF test conditions.

DOE proposes to adopt the optional test conditions as stand-alone metrics in sections 2.8 and 5.6 of appendix E. DOE proposes to adopt a new metric, E_X (where "X" represents the air temperature under which the test was conducted if not 67.5 °F), at sections 1.16 and 6.5 of appendix E for optional representations only. The metric E_X would represent the result of a test done in accordance with the UEF test procedure but at a different set of ambient test conditions. With the exception of the different temperature (both air and water) and humidity conditions, all other aspects of the test procedure would remain identical to those used to determine the regulated metric, UEF. The draw pattern used to determine E_X would be the same draw pattern used to determine UEF. The proposed optional test conditions for heat pump water heaters are shown in Table III.2.

Table III.2 Proposed Optional Test Conditions for Heat Pump Water Heaters

Heat Pump Type	Metric	Outdoor Air Conditions		Indoor Air Conditions		Supply Water Temperature
		Dry-Bulb Temperature	Relative Humidity	Dry-Bulb Temperature	Relative Humidity	
Split-System	E_5	5.0 °F	30%	67.5 °F	50%	42.0 °F
	E_{34}	34.0 °F	72%			47.0 °F
	E_{95}	95.0 °F	25%			67.0 °F
Integrated or Heat Pump-Only	E_{50}	N/A	N/A	50.0 °F	58%	50.0 °F
	E_{95}	N/A	N/A	95.0 °F	40%	67.0 °F

DOE seeks information and comments on its proposal to allow optional representations of E_X in the appendix E test procedure to indicate efficiency at different inlet air and water conditions. DOE also welcomes feedback on its proposal to use the same temperature measurement tolerances for optional E_x conditions and the required UEF condition. DOE is interested in data which can be used to determine the range of indoor ambient air conditions typical in semi-conditioned spaces in different geographical regions in the United States, and how these conditions typically correlate to outdoor air conditions. DOE is also interested in data

which may be used to correlate consumer hot water usage patterns with different seasonal conditions.

In order to avoid any potential confusion between heat pump-only water heaters and split-system water heaters, DOE is also proposing to define "split-system heat pump water heater" in section 1.14 of appendix E. Specifically, DOE proposes to adopt the definition in AWHS v8.0 with minor modifications:

> *Split-system heat pump water heater* means a heat pump-type water heater with an indoor storage tank and outdoor heat pump component.

DOE welcomes comment on its proposed definition of "split-system heat pump water heater."

DOE has tentatively determined that this proposal would not lead to additional testing costs or burden for manufacturers or test labs because these optional metrics would remain voluntary for representations.

C. Storage Tank Over-heating

As discussed in the January 2022 NOPR, DOE proposed amendments pertaining to water heaters that are designed to, or have operational modes that, raise the temperature of the stored water significantly above the outlet water temperature requirements specified in section 2.4 of appendix E. 87 FR 1554, 1580 (Jan. 11, 2022). These water heaters are meant to be used with a mixing valve (which may or may not be provided with, or be built into, the unit) to temper the outlet water to a typical outlet water temperature. Generally, raising the temperature of the water in the storage tank significantly above the target output temperature (*i.e.,* "over-heating" the water) would effectively increase the amount of hot water that a given size water heater can

deliver (*e.g.,* a 50-gallon water heater with an over-heated storage tank temperature could provide the same amount of hot water as an 80-gallon water heater with a more typical storage tank temperature). An FHR test performed at an over-heated storage tank temperature would result in a higher FHR than a test performed at a lower, more conventional storage tank temperature. The installation instructions in section 4 of appendix E do not address when a separate mixing valve should be installed, and the operational mode selection instructions in section 5.1 of appendix E do not specifically address when the water heater has an operational mode that can over-heat the water in the storage tank. However, section 5.1 of appendix E requires that the water heater be tested in its default mode, and where a default mode is not specified, to test the unit in all modes and rate the unit using the results of the most energy-intensive mode. *Id.*

For this type of water heater, DOE proposed in the January 2022 NOPR to add instructions for the installation of a mixing valve similar to what is published in section 4.1 of the ENERGY STAR Connected Test Method.[18] 87 FR 1554, 1580 (Jan. 11, 2022).

In response to the January 2022 NOPR, several commenters requested that DOE consider further amendments to the appendix E test procedure to provide more representative efficiency results for such storage-type water heaters that "over-heat" the stored water beyond the delivery temperature. These comments are summarized and responded to in the paragraphs that follow. In consideration of these comments, DOE is proposing additional testing requirements to further address water heaters that have an operational mode (or modes) that over-heat the stored water.

[18] The ENERGY STAR program published a Test Method to Validate Demand Response for connected residential water heaters on April 5, 2021 (the "ENERGY STAR Connected Test Method"). Section 4.1 of the ENERGY STAR Connected Test Method addresses the test set-up in which a separate mixing valve is required. The Energy Star Test Method to Validate Demand Response for connected residential water heaters is available at: *www.energystar.gov/sites/default/files/ENERGY%20STAR%20Connected%20Residential%20Water%20Heaters%20Test%20Method%20to%20Validate%20Demand%20Response_0.pdf* (Last accessed May 19, 2022).

NYSERDA commented that DOE should ensure that all test procedure requirements surrounding FHR enable comparison between products and accurately reflect the in-field performance of water heaters, including those which may augment capacity through the use of a mixing valve or other approaches. (NYSERDA, No. 32 at p. 4)

NEEA commented that it supports DOE's proposal to specify instructions for the installation of a mixing valve, stating that the proposal would improve repeatability and comparability of test results by providing clarity on the pipe, valve, and measurement locations. (NEEA, No. 30 at p. 2) The commenter further asserted that ensuring that inlet temperature is measured before supplying cold water to the mixing valve and that outlet temperature is measured after heating and mixing would produce the most representative and repeatable test results. (*Id*.) NEEA also recommended that DOE consider ways to account for the increased effective capacity enabled by a mixing valve (either separate or integrated). (*Id*.) According to NEEA, products that store water at a higher temperature in a mode other than default would have an increased effective capacity and lower UEF in this high temperature mode. (*Id*.) NEEA encouraged DOE to consider ways to account for the increased effective capacity for products with integrated mixing valves and those designed to be used with a mixing valve. (*Id*.)

The Joint Advocates expressed support for DOE's proposal to include instructions for the installation of a mixing valve and encouraged DOE to amend the test procedure to capture the associated increase in effective hot water storage volume for water heaters designed to be used with a mixing valve. (Joint Advocates, No. 34 at pp. 1-2) The Joint Advocates stated that raising the temperature of the stored water above the outlet water temperature requirements essentially increases the amount of hot water delivered without increasing the size of the water heater, and that this is not reflected in the test procedure or standards because water heater ratings are calculated based on the rated storage volume, not the actual effective volume. (*Id.*)

Therefore, the Joint Advocates recommended that DOE amend the test procedure to account for the additional effective storage volume enabled by a higher operating temperature and mixing valve. Specifically, the Joint Commenters encouraged DOE to consider specifying how to calculate the effective storage volume for water heaters designed to be installed with a mixing valved based on the highest possible temperature setpoint and requiring such water heaters to be tested at both 125 ±5 °F and at their highest setpoint. (*Id.*) Furthermore, the Joint Advocates commented that water heaters designed to be installed with a mixing valve should be subject to the DOE standards based on both their rated storage volume (and FHR at the 125 ± 5 °F setpoint) and their effective storage volume (and FHR at their highest setpoint). (*Id.*)

The CA IOUs stated that storage volume and first hour rating are often correlated; however, with the increased use of thermostatic mixing valves, this correlation has decreased, and FHR has become a better representation of hot water delivery than storage volume. (CA IOUs, No. 36 at p. 3) The CA IOUs asserted that the FHR metric best defines consumer amenity, and that the current standards—which are differentiated by storage volume—allow for less-efficient performance for larger volume tanks within a given test procedure bin despite delivering similar service to the consumer. (*Id.*) With regard to mixing valves specifically, the CA IOUs supported DOE's proposal to require the fitting of thermostatic mixing valves between the inlet and outlet temperature measurement points when they are not an integral component of the water heater and in the absence of manufacturer instructions. (*Id.* at p. 5) The CA IOUs stated that this requirement would align with product designs, as manufacturers typically direct the integration of a valve or its installation, making it the correct choice to ensure comparability of results and to accurately represent real-world energy use. (*Id.*)

In order to further examine the potential impact of storage tank over-heating, DOE performed testing on one 50-gallon electric resistance storage water heater that includes built-in

mixing valve and multiple user-selectable modes to boost the delivery capacity by over-heating the storage tank. DOE collected data at three different storage tank temperatures, each of which provided an outlet water temperature at 125 ±5 °F through the use of the built-in mixing valve. The maximum measured mean tank temperature after cut-out following the first draw of the 24-hour simulated use test ($\bar{T}_{max,1}$) and the average outlet water temperature during the second draw ($\bar{T}_{del,2}$) were used as indicators of over-heating. Data from this testing is shown in Table III.3 of this document. The first row of data (with maximum mean tank temperature value of 124.3) represents the unit as tested according to the current test procedure.

Table III.3 Storage Tank Over-heating Test Data

$\bar{T}_{max,1}$* (°F)	$\bar{T}_{del,2}$** (°F)	Corresponding FHR	Corresponding UEF
124.3	121.3	77 gal	0.94
144.5	124.3	81 gal	0.90
159.6	124.3	95 gal	0.88

* $\bar{T}_{max,1}$ represents the maximum measured mean tank temperature after cut-out following the first draw of the 24-hour simulated-use test.
** $\bar{T}_{del,2}$ represents the average outlet water temperature during the second draw of the 24-hour simulated-use test.

The test results support NEEA's assertion that storage tank over-heating could lead to reductions in UEF. The test configuration corresponding to the current DOE test procedure produced a UEF value of 0.94, which surpasses the threshold for compliance with the current minimum energy conservation applicable to this unit (minimum UEF of 0.93). The over-heated configurations with mean tank temperatures of 144.5 and 159.6 produced UEF values of 0.90 and 0.88, respectively, both of which are below the applicable minimum energy conservation standard for this unit.

In addition, the test results indicate that storage tank over-heating leads to an increase in the measured FHR value. The test configuration corresponding to the current DOE test procedure produced an FHR value of 77 gallons. The over-heated configurations with mean tank temperatures of 144.5 and 159.6 produced FHR values of 81 and 95 gallons, respectively. DOE

notes that an FHR of 95 gallons is comparable to that of a 100-gallon electric storage water heater.[19] By comparison, the current minimum energy conservation standard that applies to 100-gallon consumer water heaters in the high draw pattern is a UEF of 2.13 (which currently can only be achieved through heat pump technology).

From its review of publicly available product literature, products that utilize storage tank over-heating generally offer user-selectable operating modes that result in tank temperatures ranging from 100 °F to 170 °F. Based on DOE's test data, should consumers choose to operate these products to a high-capacity mode (which maintains the storage tank at, for example, 140 °F while delivering water at 125 °F), the water heater would likely perform significantly worse than a rating determined based on testing without storage tank over-heating (*i.e.*, the rated efficiency at the rated delivery capacity would not be representative of an average use cycle or period of use when operated in a high-capacity mode). Hence, DOE has tentatively determined that revisions to the method for determination of UEF and FHR are necessary to yield results representative of an average use cycle for these products. These proposed amendments are discussed in detail in the following sections.

1. Testing in Over-heated Mode

Most conventional storage-type water heaters do not include a mixing valve and offer a range of temperature setpoints that would, in typical installations, deliver outlet water at the temperature corresponding to the setpoint temperature (*e.g.*, a 140 °F setting on the water heater will deliver a 140 °F outlet temperature). Whereas, as discussed previously, water heaters that include a mixing valve and provide "over-heating" capability offer a range of internal temperature setpoints, although the outlet water remains at nominally at 125 °F regardless of internal setpoint. For the remainder of this discussion, DOE refers to a user-initiated mode that

[19] For example, DOE's Compliance Certification Database includes a 107-gallon electric storage water heater with an FHR rating of 94 gallons.

results in an elevated internal water temperature without increasing the delivered water temperature as "over-heated mode."

Currently, section 5.1 of appendix E states, "For water heaters that allow for multiple user-selected operational modes, all procedures specified in this appendix shall be carried out with the water heater in the same operational mode (*i.e.*, only one mode). This operational mode shall be the default mode (or similarly-named, suggested mode for normal operation) as defined by the manufacturer in its product literature for giving selection guidance to the consumer." An "overheated mode" in storage-type water heaters is distinct from a high-temperature setpoint because the outlet water temperature is unaffected by the internal temperature setpoint. DOE surmises that consumers who purchase a water heater that provides over-heating capability would do so with the intent to use such capability; as such, these consumers would be expected to use the over-heated mode some portion of the time, ranging from occasional use (*e.g.,* switching between the normal mode and the over-heated mode depending on the hot water capacity needed at any particular time) to regular use. Accordingly, for such products, DOE expects that a representative average use cycle would include some portion of time in over-heated mode. For this reason, DOE has tentatively concluded that testing only in the default mode would not produce results that are representative of an average use cycle or period of use for products with this capability if the default mode does not provide over-heat capability.

Considering these factors, DOE has tentatively determined that testing storage-type water heaters that offer user-selectable over-heated modes in the over-heated mode would provide a more representative result than testing in the default mode. Therefore, DOE proposes to amend section 5.1 of appendix E to require that for water heaters that offer a user-selected operational mode(s) in which the storage tank is maintained at a temperature higher than the delivery

temperature, the operational mode shall be that which results in the highest mean tank temperature while maintaining an outlet temperature of 125 ±5 °F.

DOE recognizes that the aforementioned proposal would likely cause UEF ratings for these products to decrease if they are currently certified using a default operational mode that does not initiate over-heating. In order to limit potential re-testing and re-certification burden for manufacturers, DOE is proposing that the requirement to test these products in the over-heated mode go into effect only once DOE completes its ongoing review of potential amended energy conservation standards for consumer water heaters and residential-duty commercial water heaters.[20]

Electric storage water heaters with demand-response capabilities may undergo utility-initiated over-heating during certain periods in order to store additional energy in the water heater for use during peak demand periods. This over-heating, when initiated by the electric utility company, serves an important purpose for energy storage and grid flexibility. Products that offer the ability to respond to utility-initiated over-heating requests are distinct in function from products that offer user-initiated over-heating, because demand-response water heaters do not over-heat to increase the overall daily capacity of the water heater. Instead, the capacity is only temporarily boosted to counteract the deactivation of the heating elements for extended periods of time when demand curtailment is occurring. As such, demand-response water heaters with the capability to undergo utility-initiated over-heating would not be expected increase the capacity of the water heater over a typical average use cycle in the same way that a water heater with user-initiated over-heating would, so DOE has tentatively concluded that testing demand-

[20] DOE is concurrently evaluating potential amended energy conservation standards for consumer water heaters (Docket No. EERE-2017-BT-STD-0019) and residential-duty commercial water heaters (Docket No. EERE-2021-BT-STD-0027).

response water heaters in the default/normal mode would be the most representative for demand-response water heaters.

In order to clarify which products with over-heating capability should be tested in the operational mode that results in the highest mean tank temperature while maintaining an outlet temperature of 125 ±5 °F and which products with over-heating capability should be tested in default/normal mode, DOE is proposing to define "demand-response water heater" in section 1.3 of appendix E. Products meeting that definition would be tested in normal/default mode, while all other products capable of over-heating the stored water in the tank would be tested in the in the operational mode that results in the highest mean tank temperature while maintaining an outlet temperature of 125 ±5 °F. The proposed definition for "demand-response water heater" is based on the ENERGY STAR definitions for "connected water heater product," "demand response management system," and "demand response" in specification version 5.0, with certain modifications made by DOE.[21] More specifically, DOE proposes to define "demand-response water heater" as follows:

Demand-response water heater means a storage-type water heater that –

(1) Has integrated communications hardware and additional hardware and software required to enable connected functionality with a utility or third party, which dispatches signals with demand response instructions and/or price signals to the product and receives messages from the demand-response water heater;

[21] The ENERGY STAR Version 5.0 Residential Water Heater Final Draft Specification was published on June 1, 2022 and is available online at: *www.energystar.gov/products/spec/residential_water_heaters_specification_version_5_0_pd* (Last accessed on June 4, 2022).

(2) Meets the communication and equipment standards for Consumer Technology Association Standard (CTA) 2045-B (ANSI/CTA-2045-B);[22]

(3) Automatically heats the stored water above the delivery temperature setpoint only in response to instructions received from a utility or third party.

DOE welcomes comment on its proposed definition of "demand-response water heater," including the specification for ANSI/CTA-2045-B to demonstrate connected functionality (as it is the latest version of the CTA-2045 standard).

DOE seeks comment on the proposal to specify that water heaters, except demand-response water heaters, that offer an operational mode (or modes) causing water to be stored at a temperature higher than the delivery temperature must be tested in the "over-heated mode" that results in the highest internal tank temperature while still while maintaining an outlet temperature of 125 ±5 °F. DOE also welcomes feedback on its proposal to require testing in this manner only after compliance with amended energy conservation standards for consumer water heaters and residential-duty commercial water heaters is required. DOE further seeks information and consumer use data to identify how often the over-heated mode is used in field installations.

2. Effective Storage Volume

As discussed in section III.C of this document, the Joint Advocates and the CA IOUs both recommended that the increase in water heating capacity attained through over-heating the

[22] ANSI/CTA-2045-B, "Modular Communications Interface for Energy Management," published February 2021.

storage tank be considered for energy conservation standards. The Joint Advocates suggested that compliance with standards should be based on an "effective storage volume," whereas the CA IOUs advocated for FHR to be used for standards instead of a representation of storage volume.

The current energy conservation standards at 10 CFR 430.32(d) define the minimum required UEF as a function of rated storage volume. These standards have been amended over time but are based on the original standards prescribed by EPCA at 42 U.S.C. 6295(e)(1), which also correlated the efficiency metric to storage volume. In doing so, these standards account for differences in standby losses (*i.e.,* heat transfer from the hot, stored water to the ambient surroundings) for storage tanks of varying sizes. For storage-type water heaters, the amount of hot water immediately available for consumer use has typically been governed by the storage tank size, with increased tank size resulting in a corresponding increase in standby losses. Standby losses are primarily dependent upon three factors: (1) surface area of the tank; (2) temperature of the stored water, and (3) tank insulation. As storage tank volume increases, so do the expected standby losses (all else being equal). Similarly, an increased water temperature would also increase standby losses. The standards originally prescribed by EPCA and subsequently amended by DOE did not contemplate storage tank over-heating and its potential impact on standby losses and the amount of hot water that is immediately available for consumer use. Therefore, DOE has initially concluded that a capacity metric that combines information about the tank volume and storage temperature may be more appropriate.

Similar to standby loss, the thermal energy stored in a water heater is a function of both the volume and the temperature of the water being stored in the tank. The ability to over-heat the tank increases the effective thermal energy storage of the tank to that equivalent to a larger tank that has been heated to a more conventional, lower temperature (*i.e.*, approximately 125 ±5 °F).

DOE has tentatively determined that a measure of "effective storage volume" (as suggested by the Joint Advocates) that reflects the thermal energy stored in the water heater would allow for a better comparison between a smaller water heater with over-heating and a larger water heater storing water at a lower temperature.

Lutz stated that the test procedure should be able to distinguish and measure the ability of a water heater to deliver hot water with enough energy and to deliver a high enough temperature. Lutz provided the example of a bath, where the temperature at every point during the draw is not important; contrasted with a shower, where the temperature is crucial. (Lutz, No. 35 at p. 1)

DOE notes that for activities such as filling a bathtub, consumers would benefit more from knowing the effective storage volume (*i.e.*, the volume of immediately available hot water) of a water heater, whereas for activities such as taking a shower, consumers could benefit more from knowing the FHR (*i.e.*, ability to deliver hot water for an extended period of time). In particular, FHR represents one full hour of delivery and does not necessarily describe immediate hot water availability, as FHR is also impacted by the rate of recovery. Hence, in addition to FHR, DOE has tentatively determined that effective storage volume would be a meaningful performance metric for consumers. In this SNOPR, DOE proposes a method to determine effective storage volume, V_{eff} (expressed in gallons or liters), at section 6.3.1.1 of appendix E. For water heaters storing water no higher than the delivery temperature, DOE proposes that the effective storage volume be equivalent to the measured storage volume. DOE proposes that to determine whether the stored water temperature is higher than the delivery temperature, the maximum mean tank temperature measured after cut-out following the first draw of the 24-hour simulated-use test ($\overline{T}_{max,1}$) is to be compared to the average outlet water temperature during the second draw of the 24-hour simulated-use test ($\overline{T}_{del,2}$). If $\overline{T}_{max,1}$ is less than or equal to $\overline{T}_{del,2}$, then the unit would be determined to not be capable of over-heating the stored water, and the effective

storage volume would be set equal to the measured storage volume. DOE has tentatively chosen $\overline{T}_{max,1}$ to represent the temperature of the stored water. Based on DOE's review of its own test data, $\overline{T}_{max,1}$ is typically the highest mean tank temperature achieved by the water heater, and $\overline{T}_{max}$ values throughout the test (*i.e.,* all maximum mean tank temperatures following element cut-out) typically do not vary significantly. DOE has tentatively chosen $\overline{T}_{del,2}$ to represent the delivered water temperature because it corresponds to the first draw after $\overline{T}_{max,1}$ is observed.

By contrast, for water heaters capable of over-heating water (as determined by $\overline{T}_{max,1}$ being greater than $\overline{T}_{del,2}$), DOE proposes to calculate the effective storage volume based on a volume scaling factor and data already collected during the appendix E test. The volume scaling factor would be determined as follows, which is based on the relative heat transfer rates calculated from the temperature data collected during the test:

$$k_V = \frac{\rho(\overline{T}_{max,1}) \times C_p(\overline{T}_{max,1}) \times (\overline{T}_{max,1} - 67.5°\text{F})}{\rho(125°\text{F}) \times C_p(125°\text{F}) \times (125°\text{F} - 67.5°\text{F})}$$

Where:

k_V is the dimensionless volume scaling factor;

$\rho(T)$ is the density of water evaluated at temperature T;

$C_P(T)$ is the heat capacity of water evaluated at temperature T, and

67.5 °F is the average ambient temperature.

DOE proposes to determine the effective storage volume by multiplying the measured storage volume by k_V.

DOE notes that this approach to calculating effective storage volume would allow all calculations to be based on data collected during a single 24-hour simulated use test, but it would yield meaningful results only if water heaters capable of over-heating are required to be tested in an over-heated mode, which is discussed in section III.C.1 of this document.

This SNOPR does not propose to require representations of effective storage volume, but DOE may consider such requirements as part of a future energy conservation standards rulemaking, should this proposal be finalized.

With respect to the comment from the CA IOUs suggesting that the energy conservation standards be based on FHR rather than storage volume, DOE notes that changes to the energy conservation standards are outside the scope of this test procedure rulemaking. However, this recommendation, along with the Joint Advocates' recommendation that standards be based on an effective volume, will be considered further in DOE's concurrent energy conservation standards rulemaking.

DOE seeks comment on its tentative determination that effective storage volume would be a meaningful performance metric for consumers and is a more appropriate measure of thermal energy storage than FHR.

DOE seeks comment on the proposed equations and approach to calculating effective storage volume for water heaters.

D. Separate Storage Tank Requirements

Some water heaters on the market require a volume of water, typically contained in either a storage tank (or tanks) or in a piping distribution system of sufficient volume, to operate. These products operate by circulating water stored either in the piping system or from a separate tank (or multiple separate tanks) to the water heater to be heated then back to the piping system or tank until hot water is needed. In the January 2022 NOPR, DOE identified two types of products that require a volume of water to operate – heat pump-only water heaters that require installation with a separate storage tank and circulating gas-fired instantaneous water heaters that require installation with a separate storage tank or a piping system of sufficient volume. 87 FR 1554, 1583-1585 (Jan. 11, 2022). Circulating gas-fired instantaneous water heaters are distinct from other types of gas-fired instantaneous water heaters in that they are not designed to operate independent of a storage tank or hot water system, as other gas-fired instantaneous water heaters are. This applies generally to circulating water heaters; however, DOE has tentatively determined that there are no electric resistance or oil-fired circulating water heaters on the market today.

The current test procedure does not have procedures in place to appropriately test circulating water heaters. As such, in the January 2022 NOPR, DOE proposed to define "circulating water heater" (including both heat pump-only and gas-fired instantaneous circulating water heaters) and to require that such products be tested using an 80 gallon (± 1 gallon) unfired hot water storage tank ("UFHWST") that meets the energy conservation standards for an unfired hot water storage tank at 10 CFR 431.110(a). 87 FR 1554, 1583-1585 (Jan. 11, 2022).

In response to the January 2022 NOPR, DOE received a number of comments regarding the separate storage tank requirements, primarily related to the ± 1 gallon tolerance, the representativeness of an 80-gallon unfired hot water storage tank, and the lack of a specification

for the upper bound on thermal insulation for the unfired hot water storage tank. These comments are summarized and addressed in the paragraphs that follow.

NYSERDA commented that an 80-gallon UFHWST may not be the correct tank to use to increase repeatability and represent real world conditions. (NYSERDA, No. 32 at p. 2)

Rheem commented that because a circulating water heater can be paired with multiple sizes of tanks (*e.g.*, 40-, 60-, and 80-gallon tanks), DOE should consider multiple tank sizes for testing circulating water heaters instead of just one 80-gallon storage tank. Rheem also suggested that DOE increase the tolerance on the volume of the storage tank to match the tolerance prescribed by product safety standards,[23] noting that a ±1 gallon tolerance on an 80-gallon storage volume is too tight. Rheem also requested clarification on whether the separately sold storage tank may have backup heating (*e.g.*, if the circulating water heater is designed to be used with a tank that has backup heating) and whether the two products could be rated together as a system. (Rheem, No. 40 at pp. 3-4)

AHRI recommended that DOE not adopt a ±1 gallon tolerance requirement for the storage tank used in the test for a heat pump-only water heater, stating that DOE should instead apply 10 percent volume tolerance, consistent with UL standard 174 or UL standard 1453. AHRI also suggested that manufacturers be allowed to specify the storage tank used to determine ratings for circulating and heat pump-only water heaters. (AHRI, No. 40 at pp. 3-5)

A.O. Smith stated that it would not be unduly burdensome to use an 80-gallon tank for heat pump-only water heater testing. However, A.O. Smith stated that tank insulation, inlet and

[23] DOE understands this to be a reference to the 10 percent by volume tolerances prescribed by UL Standard 174 ("Household Electric Storage Tank Water Heaters") and UL Standard 1453 ("Standard for Electric Booster and Commercial Storage Tank Water Heaters"). These standards can be found online at *www.shopulstandards.com* (Last accessed on June 21, 2022).

outlet connection locations, internal tank baffling, and inlet tube designs could impact the UEF result, and accordingly, these variables should be addressed in the DOE test procedure. A.O. Smith recommended that, to minimize as many variables as possible, manufacturers be required to provide the model number of the specific tank as part of its certification data, and that the test tank should be defined as a part of the test apparatus. (A.O. Smith, No. 37 at p. 3) DOE understands this to mean that A.O. Smith recommends that the UFHWST model number used for testing UEF be certified to DOE by the manufacturer, and that appendix E should indicate that the specific UFHWST model certified to DOE must be used in the test set-up.

The CA IOUs stated that the proposed 80-gallon tank size may not reflect real-world applications. Additionally, the CA IOUs argued that because the proposed requirement would impose a minimum R-value for the tank, but no maximum, it could lead to variations in test outcomes. The CA IOUs suggested that heat pump-only water heater manufacturers should be allowed to test their products with a manufacturer-specified storage tank and certify the information about the tank used for testing. The CA IOUs also suggested that for heat-pump-only water heaters, DOE should specify a traditional consumer electric storage water heater tank, as it may be more representative of actual use. (CA IOUs, No. 36 at p. 5; CA IOUs, No. 27 at p. 31)

BWC commented that not all storage tanks are designed identically, and differences in tank design may lead to differences in ratings for circulating and heat pump-only water heaters. BWC also urged DOE to not adopt a 1-gallon tolerance on the volume of an 80-gallon storage tank, but instead to use a 10-percent tolerance. BWC requested that DOE clarify whether the 80-gallon requirement would pertain to nominal capacity. (BWC, No. 33 at p. 9)

After considering the issues raised by commenters, DOE is proposing several updates to its earlier proposals (in section 4.10 of appendix E) for testing circulating water heaters as initially presented in the January 2022 NOPR.

First, after re-evaluating the market for heat-pump-only water heaters, DOE tentatively agrees with the CA IOUs that testing such products with a conventional electric storage water (*i.e.*, an electric water heater that uses only electric resistance heating elements) would be more representative than testing with an UFHWST. Therefore, DOE is proposing that heat-pump-only water heaters be tested in the medium draw pattern using a 40-gallon traditional electric storage tank (*i.e.*, that provides heat only with electric resistance heating elements) that has a UEF rating at the minimum required at 10 CFR 430.32(d). DOE chose a 40-gallon tank in the medium draw pattern because that size and draw pattern combination has the highest number of models currently available on the market.[24] DOE is also proposing that, for heat pump-only water heaters, the test be carried out using a tank that does not "over-heat" the stored water (see discussion of over-heating in section III.C of this document; $\overline{T}_{max,1}$ (maximum measured mean tank temperature after the first recovery period of the 24-hour simulated-use test) must be less than or equal to $\overline{T}_{del,2}$ (average outlet water temperature during the 2nd draw of the 24-hour simulated-use test)). This would ensure that the electric storage tanks are not overheating during the test, thereby ensuring consistency across tests.

In contrast, DOE is maintaining its earlier proposal that a UFHWST be used for testing of circulating gas-fired water heaters, as those products are more likely to be installed with a UFHWST in the field. Therefore, DOE tentatively concludes that testing with an UFHWST would be representative for such units.

[24] *See* Figure 3A.2.8 of the Preliminary Analysis Technical Support Document for consumer water heaters (Docket No. EERE-2017-BT-STD-0019-0018).

In response to AHRI's suggestion that DOE allow manufacturers to specify the storage tank used for testing, DOE notes that this approach could lead to additional test burden for third-party testing labs, who may need to acquire more than one storage tank if they are performing tests for multiple manufacturers, each of whom may specify a different storage tank for testing. In order to avoid creating the potential for additional test burden, DOE has tentatively determined not to allow manufacturers to specify the electric storage water heater or unfired hot water storage tank used respectively for testing the heat pump-only or gas-fired instantaneous circulating water heaters. Additionally, DOE will consider relevant amendments to certification and reporting requirements in a separate rulemaking.

After considering the comments regarding the tolerance on the storage tank initially proposed in the January 2022 NOPR, DOE has tentatively determined that a wider tolerance would reduce potential testing burden while still providing representative and reproducible results. In other words, DOE tentatively concludes that a 10-percent tolerance would increase flexibility for manufacturers by increasing the number of tanks that could be used for testing, while not materially impacting the UEF test results. Therefore, consistent with the recommendations provided by commenters, DOE is proposing to adopt a 10 percent tolerance (±10 percent, allowing products with rated storage volumes between 36 gallons and 44 gallons) for the electric storage water heater used for testing heat-pump-only water heaters.

In addition, after further review of the market for circulating gas-fired instantaneous water heaters and unfired hot water storage tanks, DOE is proposing to allow testing with a tank at any storage volume between 80- and 120-gallons. Based on further analysis, DOE has tentatively determined that variations in the tank size should not significantly impact the result of the test. During a water draw, the internal tank temperature decreases as hot water exits the tank and is replenished by colder water entering the tank. Generally, different tank sizes will result in

different rates of internal temperature decrease during a water draw (*e.g.*, during a specified water draw, a smaller tank will generally experience a faster decrease in temperature compared to a larger tank). During a test, any potential differences in the tank water temperature due to the use of different size tanks would be accompanied by a corresponding proportional difference in burner on-time, such that the impact on measured efficiency (*i.e.*, the ratio of energy output to energy input) would be negligible. DOE also recognizes that a larger tank would likely have more standby losses than a smaller tank; however, DOE has tentatively determined that the impact this would have on measure efficiency would also not be significant.

Providing a range of allowable tank volumes would reduce potential burden by providing manufacturers with more tank options, thereby allowing them to pair their circulating gas-fired instantaneous water heaters with an existing UFHWST model. This approach is also likely to be more representative of how the units would be installed in the field as opposed to testing with a custom-made tank for testing or a competitor's tank that meets a specific volume requirement.

DOE notes that, as suggested by the CA IOUs and A.O. Smith, the lack of an upper bound on the thermal insulation value for the UFHWST could lead to differences in measured efficiency that reflect differences in tank performance, rather than reflecting differences in water heater performance. Therefore, DOE has tentatively determined that more specific constraints on tank performance are warranted to ensure more comparable test results across the subject water heater models. Thus, DOE is proposing to require that UFHWSTs used for testing circulating gas-fired instantaneous water heaters exactly meet the baseline energy conservation standard for UFHWSTs.[25] As stated previously, A.O. Smith raised the concern that differences in the UFHWST's design (insulation, inlet and outlet connection locations, internal tank baffling, and inlet tube designs) could lead to variation in UEF results; however, A.O. Smith and other

[25] Currently, baseline energy conservation standards for UFHWSTs require a thermal insulation of R-12.5. 10 CFR 431.110(a).

commenters did not provide suggestions on specific UFHWST designs which should be standardized in order to improve representativeness and repeatability of the test method. A.O. Smith did not provide any data to demonstrate these to be significant concerns. While the variations in insulation would most significantly impact the standby losses of the tank (and therefore the UEF rating of the circulating water heater), these variations would already be minimized by specifying the R-value of the UFHWST to be the baseline requirement in the energy conservation standards for UFHWSTs. Regarding the other design options, over-specifying the design of the UFHWST—given the impacts on the UEF rating are minimal—could result in a very narrow range of UFHWST models which can be used for testing circulating water heaters, thereby potentially introducing significant barriers to testing these products at third-party laboratories. Additionally, DOE does not currently have sufficient information on specifications for the inlet and outlet connection locations, internal tank baffling, and inlet tube designs for the UFHWST; therefore, DOE is not including these specifications in its proposed requirements.

As noted previously, DOE is similarly proposing that the electric storage water heater used for testing heat-pump-only water heaters have a rated UEF corresponding to the minimum standard found at 10 CFR 430.32(d), thereby helping to ensure more comparable results.

In summary, in this SNOPR, DOE proposes to further amend the separate storage tank requirements proposed in the January 2022 NOPR for heat pump-only and gas-fired circulating water heaters. DOE proposes that heat pump-only water heaters be tested with a 40-gallon (± 4 gallons) electric storage water heater that has a UEF value corresponding to the minimum standard for such products; and that gas-fired circulating water heaters be tested with an 80- to 120-gallon unfired hot water storage tank that is rated equal to the energy conservation standard for such equipment.

DOE requests comment on its proposed separate tank requirements for heat pump-only and gas-fired circulating water heaters. DOE also seeks comment on whether any additional tank characteristics should be specified.

For gas-fired circulating water heaters, these proposed changes could require a one-time purchase of an 80- to 120-gallon unfired hot water storage tank. DOE research indicates that such tanks are readily commercially available for approximately $2,000. For heat pump-only water heaters, the proposed changes could result in a one-time purchase of a 40-gallon (± 4 gallons) electric storage water heater. DOE research indicates that such water heaters are readily available for approximately $500. These estimates reflect costs for third-party laboratory testing (*i.e.*, assuming these tanks would have to be purchased at retail price).

DOE seeks comment on the estimated potential increase in costs for testing heat pump-only and gas-fired circulating water heaters according to this proposal.

Finally, although this SNOPR does not propose changes to the certification requirements, DOE may consider a requirement to certify the UFHWST and electric storage water heater models and/or characteristics in a future rulemaking.

E. Method for Determining Internal Tank Temperature for Certain Water Heaters

As discussed in the January 2022 NOPR, section 4.5 of appendix E specifies that the thermocouples be inserted into the storage tank of a water heater through either the anodic device opening, the temperature and pressure relief valve, or the outlet water line. DOE has identified consumer water heaters with physical attributes that make measuring internal storage tank temperature using any of these means difficult, such as water heaters that have a built-in mixing valve and no anodic device, or have a large heat exchanger that does not accommodate insertion

of a thermocouple tree. 87 FR 1554, 1586 (Jan. 11, 2022). Commenters on the April 2020 RFI suggested an approach whereby the tank would be drained down to measure the temperature of the water inside. *Id*. In the January 2022 NOPR, DOE explained how draining down the tank would not be possible in the middle of the 24-hour simulated use test, when mean tank temperature data is required. *Id*. Therefore, DOE proposed that the internal tank temperature for these products would be approximated as the average between the inlet and outlet temperatures (*i.e.*, a "linear temperature gradient" assumption). *Id*.

Rheem agreed with DOE's proposed methodology to estimate the mean tank temperature for products for which the internal tank temperature cannot be directly measured. (Rheem, No. 31 at p. 4)

However, several commenters indicated that the linear temperature gradient assumption inherent to the proposed methodology in the January 2022 NOPR is incorrect. AHRI commented that the proposed procedure incorrectly assumes a linear temperature gradient in the tank, which can lead to inaccurate calculation of temperature and stored energy in the tank.[26] (AHRI, No. 40 at p. 5)

A.O. Smith commented that it has conducted testing using the proposed test method and has found that the assumption of a linear temperature gradient is inaccurate when compared to actual temperature readings conducted with thermocouples. Accordingly, A. O. Smith concluded that it would be premature to incorporate the proposed test method into the DOE test procedure at this time. (A. O. Smith, No. 37 at pp. 5-6) BWC indicated that, based on its own

[26] Additionally, AHRI stated that the procedure should require measurements to be taken 15 seconds after the initial draw to be consistent with other proposals.

testing, the proposed methodology could record artificially lower tank temperatures, with errors as high as 10 to 25 percent. (BWC, No. 33 at p. 10)

In the final rule that established the current test procedure for commercial water heaters, DOE noted that using the average of the supply and outlet water temperature as an estimate for the stored water temperature is only valid if the water temperature inside the heat exchanger has a linear increase in temperature as it moves from the inlet to the outlet. 81 FR 79261, 79295 (Nov. 10, 2016). In order to estimate the internal tank temperature for commercial instantaneous water heaters and hot water supply boilers, DOE adopted a method that uses the outlet water temperature as an approximation, because it was consistent with the industry-adopted test method for flow-activated instantaneous water heaters, found at Annex E.3 of ANSI Standard Z21.10.3-2015. *Id*.

However, as discussed in section III.C of this SNOPR, DOE is aware of consumer water heaters that can store water at temperatures that are significantly higher than the outlet temperature, so the method used for commercial instantaneous water heaters and hot water supply boilers would not be applicable to all types of products covered under this rulemaking. Furthermore, outlet water temperature would only be representative of the internal tank temperature for consumer water heaters and residential-duty commercial water heaters with very limited storage volume, where the small volume prevents internal temperature stratification.[27]

Based on further consideration of comments received in response to the January 2022 NOPR and at previous stages of this rulemaking, DOE is proposing in this SNOPR that, for water heaters with rated storage volumes greater than or equal to 2 gallons that are unable to have their internal tank temperatures measured using thermocouples, the internal tank

[27] Currently, mean tank temperature measurements are not required for consumer water heaters or residential-duty commercial water heaters less than 2 gallons in rated storage volume.

temperature shall be estimated by removing water from the water heater, as described in detail in the following paragraphs. This method, proposed in a new section 5.4.2.2 of appendix E, is partially based on the approaches suggested by Rheem and BWC prior to the January 2022 NOPR (*see* Document No. EERE-2019-BT-TP-0032-0012 at p. 5 and Document No. EERE-2019-BT-TP-0032-0014 at p. 9), with certain modifications.

As discussed in the January 2022 NOPR, throughout the 24-hour simulated-use test, internal tank thermocouples are used to determine the mean tank temperature. Mean tank temperatures are required at the start and end of the test, the start and end of the standby period, and the after the first recovery period (*i.e.*, $\overline{T}_0$, $\overline{T}_{24}$, $\overline{T}_{su,0}$, $\overline{T}_{su,f}$, and $\overline{T}_{max,1}$, respectively). Also, an average mean tank temperature throughout the standby period is required (*i.e.*, $\overline{T}_{t,stby,1}$). 87 FR 1554, 1586 (Jan. 11, 2022). DOE performed an analysis on data collected from its own testing and has initially concluded that, for typical storage-type water heaters, $\overline{T}_0$, , $\overline{T}_{su,0}$, and $\overline{T}_{max,1}$ are similar in that they represent temperatures near the cut-out control temperature. Removing the heated water from the tank and measuring the temperature, as described in detail below, immediately after cut-out may reasonably estimate these temperatures. The mean tank temperature at the end of the standby period, $\overline{T}_{su,f}$, can also be measured by removing water and measuring its temperature at the end of a sufficiently long standby period at the end of the test, and this value could also approximate $\overline{T}_{24}$.

In this SNOPR, DOE is proposing the following methodology for water heaters with rated storage volumes greater than or equal to 2 gallons that are unable to have their internal tank temperatures measured using thermocouples:

(1) After the FHR test (for non-flow-activated products) or Max GPM test (for flow-activated products), allow the water heater to fully recover.

(2) When cut-out occurs, deactivate the burner, compressor, and/or electrical heating elements.

(3) Remove the hot water from the tank by performing a continuous draw, while measuring the outlet water temperature at 3-second intervals, until the outlet water temperature is within 2 °F of the inlet water temperature for five consecutive readings. Perform the draw at a flow rate of 3.0 gallons per minute (±0.25 gallons per minute). Compute the mean tank temperature, $\overline{T}st$, as follows and assign this value as $\overline{T}0$, $\overline{T}su,0$, and $\overline{T}max,1$:

$$\overline{T}_{st} = T_p - \frac{v_{out,p}}{V_{st}} \times \tau_p(\overline{T}_{in,p} - \overline{T}_{out,p})$$

Where:

$\overline{T}_{st}$ = the estimated average internal storage tank temperature.

T_p = the average of the inlet and the outlet water temperatures at the end of the period defined by τ_p.

$v_{out,p}$ = the average flow rate during the period.

V_{st} = the rated storage volume of the water heater.

τ_p = the duration of the period, determined by the length of time taken for the outlet water temperature to be within 2 °F of the inlet water temperature for 15 consecutive seconds. The duration of the period shall include the 15-second stabilization period.

$\overline{T}_{in,p}$ = the average of the inlet water temperatures during the period.

$\overline{T}_{out,p}$ = the average of the outlet water temperatures during the period.

(4) Re-activate the burner, compressor, and/or electrical elements and perform the 24-hour simulated use test as instructed in section 5.4 of appendix E.

(5) The standby period will start at five minutes after the end of the first recovery period after the last draw of the simulated-use test. The standby period shall last eight hours, so testing will extend beyond the 24-hour duration of the simulated-use test. At the end of the final standby measurement, remove water from the tank once again as in step #3, including computing the value of mean tank temperature. This calculated mean tank temperature is then assigned as $\overline{T}$su,f and $\overline{T}$24.

(6) Determine $\overline{T}$t,stby,1 as the average of $\overline{T}$su,0 and $\overline{T}$su,f.

DOE seeks comment on its revised proposed test method to determine the internal tank temperature for water heaters that cannot be directly measured and are greater than or equal to 2 gallons in rated storage volume.

DOE estimates that, at maximum, the proposed method for estimating the internal tank temperature would increase the test duration by 8 hours (corresponding to the final standby period appended to the current 24-hour simulated use test). DOE estimates that the testing a water heater to the 24-hour simulated use test currently costs $3,000 for a fossil-fuel-fired or electric water heater and $4,500 for a heat pump water heater. By extending the duration of the test by up to 8 hours (or 33 percent), this amendment, if finalized, could increase testing costs by $1,000 to $1,500 per basic model for water heaters with rated storage volume greater than or

equal to 2 gallons which cannot have their internal storage tank directly measured. However, these products are designed in such a way that instruments for measuring the internal water temperature cannot be installed, and, thus, these products cannot be tested to the current version of appendix E.

IV. Procedural Issues and Regulatory Review

A. Review Under Executive Orders 12866 and 13563

Executive Order ("E.O.")12866, "Regulatory Planning and Review," 58 FR 51735 (Oct. 4, 1993), as supplemented and reaffirmed by E.O. 13563, "Improving Regulation and Regulatory Review," 76 FR 3821 (Jan. 21, 2011), requires agencies, to the extent permitted by law, to: (1) propose or adopt a regulation only upon a reasoned determination that its benefits justify its costs (recognizing that some benefits and costs are difficult to quantify); (2) tailor regulations to impose the least burden on society, consistent with obtaining regulatory objectives, taking into account, among other things, and to the extent practicable, the costs of cumulative regulations; (3) select, in choosing among alternative regulatory approaches, those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts; and equity); (4) to the extent feasible, specify performance objectives, rather than specifying the behavior or manner of compliance that regulated entities must adopt; and (5) identify and assess available alternatives to direct regulation, including providing economic incentives to encourage the desired behavior, such as user fees or marketable permits, or providing information upon which choices can be made by the public. DOE emphasizes as well that E.O. 13563 requires agencies to use the best available techniques to quantify anticipated present and future benefits and costs as accurately as possible. In its guidance, the Office of Information and Regulatory Affairs ("OIRA") in the Office of Management and Budget ("OMB") has emphasized that such techniques may include identifying

changing future compliance costs that might result from technological innovation or anticipated behavioral changes. For the reasons stated in the preamble, this proposed regulatory action is consistent with these principles.

Section 6(a) of E.O. 12866 also requires agencies to submit "significant regulatory actions" to OIRA for review. OIRA has determined that this proposed regulatory action does not constitute a "significant regulatory action" under section 3(f) of E.O. 12866. Accordingly, this action was not submitted to OIRA for review under E.O. 12866.

B. Review Under the Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*) requires preparation of an initial regulatory flexibility analysis ("IRFA") for any rule that by law must be proposed for public comment, unless the agency certifies that the rule, if promulgated, will not have a significant economic impact on a substantial number of small entities. As required by Executive Order 13272, "Proper Consideration of Small Entities in Agency Rulemaking," 67 FR 53461 (August 16, 2002), DOE published procedures and policies on February 19, 2003, to ensure that the potential impacts of its rules on small entities are properly considered during the DOE rulemaking process. 68 FR 7990. DOE has made its procedures and policies available on the Office of the General Counsel's website: *www.energy.gov/gc/office-general-counsel*. DOE reviewed this test procedure SNOPR under the provisions of the Regulatory Flexibility Act and the policies and procedures previously published on February 19, 2003.

The following sections detail DOE's IRFA for this test procedure rulemaking.

1. Description of reasons why action is being considered

DOE is proposing to amend test procedures for consumer water heaters and residential-duty commercial water heaters. DOE is publishing this rulemaking in satisfaction of the 7-year-lookback review requirement specified in EPCA. (42 U.S.C. 6293(b)(1)(A); 6314(a)(1)) Further, amending test procedures for consumer and residential-duty commercial water heaters assists DOE in fulfilling its statutory deadline for amending energy conservation standards for products and equipment that achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A); 42 U.S.C. 6313(a)(6)) Additionally, amending test procedures for consumer and residential-duty commercial water heaters allows manufacturers to produce measurements of energy efficiency that are representative of an average use cycle and uniform for all manufacturers.

On January 11, 2022, DOE published a test procedure NOPR ("January 2022 NOPR") in the *Federal Register* proposing to amend the test procedure for consumer water heaters and residential-duty commercial gas water heaters. *See* 87 FR 1554, 1590-1592. In this SNOPR, DOE proposes modifications to the January 2022 NOPR.

2. Objectives of, and legal basis for, rule

EPCA authorizes DOE to regulate the energy efficiency of a number of consumer products and certain industrial equipment, including the consumer and residential-duty commercial water heaters that are the subject of this proposed rulemaking. (42 U.S.C. 6292(a)(4) and 42 U.S.C. 6311(1)(K))

3. Description and estimate of small entities regulated

For manufacturers of consumer water heaters and residential-duty commercial water heaters, the Small Business Administration (SBA) has set a size threshold, which defines those

entities classified as "small businesses" for the purposes of the statute. DOE used the SBA's small business size standards to determine whether any small entities would be subject to the requirements of the rule. (*See* 13 CFR part 121.) The size standards are listed by North American Industry Classification System ("NAICS") code and industry description and are available at: *www.sba.gov/document/support--table-size-standards*. Manufacturing of consumer water heaters and residential-duty commercial water heaters is classified under NAICS 335220, "Major Household Appliance Manufacturing." The SBA sets a threshold of 1,500 employees or fewer for an entity to be considered as a small business for this category. DOE used available public information to identify potential small manufacturers. DOE accessed CCMS,[28] the certified product directory of the AHRI,[29] company websites, and manufacturer literature to identify companies that import, private label, or produce the consumer water heaters and residential-duty commercial water heaters covered by this proposal. Using these sources, DOE identified a total of 27 manufacturers of consumer water heaters and residential-duty commercial water heaters. Of these 27 manufacturers, DOE identified one domestic small business that manufactures products covered by the proposed test procedure amendments in this SNOPR.

4. Description and estimate of compliance requirements

As noted previously, DOE conducted an initial regulatory flexibility analysis ("IRFA") as part of the January 2022 NOPR, in which it determined that there is one domestic, small business that manufactures residential water heaters impacted by the January 2022 NOPR. *Id.* at 87 FR 1591. Under the proposed amendments in the January 2022 NOPR, DOE anticipated the small business would incur third-party re-testing costs of $4,500 for one basic model as result of DOE's proposal to require the use of a separate unfired hot water storage tank for testing water

[28] U.S. Department of Energy Compliance Certification Management System, available at: *www.regulations.doe.gov/ccm*s. (Last accessed March 1, 2022).
[29] AHRI Directory of Certified Product Performance, available at: *www.ahridirectory.org/Search/SearchHome.* (Last accessed March 1, 2022).

heaters designed to operate with a separately sold hot water storage tank. DOE estimated the compliance burden to represent less than 0.01 percent of the company's revenue. *Id*.

This SNOPR serves to: (1) provide additional specificity for the existing test procedure for water heaters with a rated storage volume of less than 2 gallons; (2) propose optional rating conditions and associated metrics for voluntary representations of heat pump water heaters; (3) revise the separate storage tank requirements for circulating water heaters proposed in the January 2022 NOPR; (4) provide instructions for testing water heaters which store water at a temperature higher than the delivery setpoint and for determining the effective storage volume of such products, and (5) revise the testing requirements for water heaters which are greater than or equal to 2 gallons in rated storage volume but cannot have the temperature of their internal storage tanks directly measured. Each of these proposed amendments will be discussed in turn to assess their potential impacts in light of the Regulatory Flexibility Act.

First, DOE proposes to add flow rate tolerances for the 24-hour simulated-use test for water heaters with a rated storage volume of less than 2 gallons. DOE expects that laboratories may utilize high-precision water flow rate instrumentation (*e.g.,* Coriolis flow meters) to meet the proposed flow rate tolerances. DOE is aware of multiple third-party laboratories which already incorporate Coriolis flow meters for DOE compliance testing. Further, DOE expects that general industry best practice is already applying the flow rate tolerances being proposed for section 5.4.3 of appendix E for water heaters with rated storage volume less than 2 gallons; therefore, this proposal is expected to be consistent with current methodology and practice.

Additionally, DOE has tentatively determined that the proposed amendment would not alter the measured efficiency of consumer water heaters and residential-duty commercial water heaters, nor require retesting or recertification solely as a result of DOE's adoption of the

proposed amendments to the test procedure. For these reasons, DOE has initially determined that the proposed tolerances would generally not impose additional testing burden.

Second, DOE is proposing to adopt optional test conditions and metrics for voluntary representations of heat pump water heater energy efficiency at test conditions other than the standard rating conditions. If adopted in a final rule, these metrics will not be required for reporting or compliance with standards for consumer water heaters and residential-duty commercial water heaters. Therefore, DOE has initially determined that testing for these optional metrics would not be unduly burdensome to conduct.

Third, DOE previously proposed separate storage tank requirements for testing circulating water heaters in the January 2022 NOPR. 87 FR 1554, 1589 (Jan. 11, 2022). In the January 2022 NOPR, DOE proposed that circulating water heaters (including heat pump-only water heaters) be tested paired with 80-gallon unfired hot water storage tanks which meets the energy conservation standard requirements at 10 CFR 431.110(a). *Id*. In this SNOPR, DOE is instead proposing to require circulating gas-fired instantaneous water heaters and heat pump-only water heaters to be paired with different types of tanks to be more representative of field installations.

For circulating gas-fired instantaneous water heaters, DOE proposes that these products be paired with UFHWSTs that exactly meet baseline energy conservation standards (as required at 10 CFR 431.110(a)) and rated at a capacity between 80 gallons and 120 gallons. Compared to the January 2022 NOPR, DOE applied additional specificity to the tank performance constraints to improve reproducibility of the test method and increased the range of acceptable capacities after reviewing market data on which capacities are commercially available at the baseline energy conservation standard level.

DOE estimates that the cost of running the amended test procedure for circulating gas-fired instantaneous water heaters should be the same as testing a comparable water heater with storage volume (*i.e.*, third-party testing of a fossil fuel-fired or electric storage water heater would cost approximately $3,000 and third-party testing of an electric storage water heater which uses heat pump technology would cost approximately $4,500). However, DOE is not aware of any domestic small manufacturers of circulating gas-fired instantaneous water heaters at this time.

For heat pump-only water heaters, DOE is updating its proposal to propose that these products be paired with electric storage water heaters that have a rated storage volume of 40 gallons ± 4 gallons, have an FHR that results in classification at the medium draw pattern, and be rated at exactly the minimum required UEF. Compared to the January 2022 NOPR, DOE is proposing a different type and size of product to be paired with a heat pump-only water heater to better reflect how heat pump-only water heaters may be installed in the field.

DOE estimates that the cost of running the amended test procedure for heat pump-only water heaters should be the same as testing a comparable water heater with storage volume. For this estimate, DOE utilized a third-party test estimate of $4,500. DOE believes this to represent the high-end range of the testing cost burden compared to in-house testing.

DOE is aware of one domestic small manufacturer which has a single model that would be affected by this amendment. DOE expects the cost to test that model per the test method proposed in this SNOPR to be $4,500. This represents less than 0.01 percent of company revenue, and, therefore, DOE has tentatively determined that it would not be unduly burdensome to conduct.

Fourth, DOE is proposing to require that water heaters, except for demand-response water heaters, which can store water at a temperature higher than the delivery setpoint as a result of a user-selected operating mode be tested using the setting that provides the highest internal mean tank temperature while delivering water at a temperature of 125 °F ±5 °F, and that an "effective storage volume" – which quantifies the increase in energy storage due to this mode of operation – be calculated for all storage water heaters based on data that is already being collected per the current appendix E test procedure. This proposal, if adopted, would improve representativeness and reproducibility for water heaters with such a capability.

The proposed amendment to test in an "over-heated" mode could potentially lead to re-testing and re-certification costs for manufacturers of such water heaters, as it would impact the UEF rating of such products. Should a manufacturer be required to re-testing, DOE estimates re-testing costs to be up to $4,500 per basic model using third-party testing. DOE believes this to represent the high-end range of the testing cost burden compared to in-house testing.

DOE is not proposing to require compliance with this provision until compliance with amended energy conservation standards is also required (after the date of a final rule amending the test procedure for consumer water heaters and residential-duty commercial water heaters). Therefore, DOE has tentatively determined that this proposed amendment, if adopted, would not impose additional costs for manufacturers until such time as potential amended standards would be required. DOE will consider these impacts in a separate rulemaking as part of its ongoing review of potential amended energy conservation standards.

Lastly, there is currently no method to determine ratings for water heaters which have rated storage volumes of 2 gallons or more but cannot have the internal storage tank temperature directly measured by means of the instrumentation required in the appendix E test procedure.

The use of standard instrumentation is limited by the geometries of these products. Examples of such cases include products which have built-in mixing valves at the water outlet, products which do not use a sacrificial anode rod (and therefore do not have the associated opening for the anode rod), or products with complex heat exchanger geometries. DOE previously proposed to rely on inlet and outlet water temperatures to approximate the internal storage tank temperatures for these water heaters. 87 FR 1554, 1586 (Jan. 11, 2022). However, in this SNOPR, DOE is revising its proposed methodology for determining the internal tank temperatures of such products to improve the accuracy as compared to the method originally proposed in the January 2022 NOPR.

The method proposed in this SNOPR relies on drawing out water from the tank at the beginning and end of the 24-hour simulated use test and monitoring the temperature of the water as it is drawn out to estimate the internal tank temperature of the stored water prior to being drawn out of the water heater. This method may result in overall testing costs of $4,000 to $6,000 per basic model of water heater which cannot be directly measured. This is comparable to the average cost of $3,000 to $4,500 per basic model of water heater which can be directly measured. DOE is currently not aware of any small businesses which produce water heaters which will have to be tested in this manner, and, thus, DOE has tentatively concluded that this amendment, if finalized, would not impact small manufacturers.

DOE requests comment on its understanding of the cost impacts of the proposed amendments in this notice on small, domestic manufacturers.

5. Duplication, overlap, and conflict with other rules and regulations

DOE is not aware of any rules or regulations that duplicate, overlap, or conflict with the rule being considered today.

6. Significant alternatives to the rule

The discussion in the previous section analyzes impacts on small businesses that would result from DOE's proposed test procedure, if finalized. In reviewing alternatives to the proposed test procedure, DOE examined not establishing a performance-based test procedure for consumer and residential-duty commercial water heaters or establishing prescriptive-based test procedures. While not establishing performance-based test procedures or establishing prescriptive-based test procedures for consumer and residential-duty commercial water heaters would reduce the burden on small businesses, DOE must use test procedures to determine whether the products comply with relevant standards promulgated under EPCA. (42 U.S.C. 6295(s)) Because establishing performance-based test procedures for consumer and residential-duty commercial water heaters is necessary prior to establishing performance-based energy conservation standards, DOE tentatively concludes that establishing performance-based test procedures, as proposed in this SNOPR, supports DOE's authority to achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. (42 U.S.C. 6295(o)(2)(A); 42 U.S.C. 6313(a)(6)(A)(ii)(II))

The Department has tentatively determined that there are no better alternatives than the test procedures amendments proposed in this SNOPR, in terms of both meeting the agency's objectives and reducing burden. Additionally, manufacturers subject to DOE's test procedures may apply to DOE's Office of Hearings and Appeals for exception relief under certain circumstances. Manufacturers should refer to 10 CFR part 430, subpart E, and 10 CFR part 1003 for additional details.

C. Review Under the Paperwork Reduction Act of 1995

Manufacturers of consumer and residential-duty commercial water heaters must certify to DOE that their products comply with any applicable energy conservation standards. To certify compliance, manufacturers must first obtain test data for their products according to the DOE test procedures, including any amendments adopted for those test procedures. DOE has established regulations for the certification and recordkeeping requirements for all covered consumer products and commercial equipment, including consumer and residential-duty commercial water heaters. (*See generally* 10 CFR part 429.) The collection-of-information requirement for certification and recordkeeping is subject to review and approval by OMB under the Paperwork Reduction Act ("PRA"). This requirement has been approved by OMB under OMB control number 1910-1400. Public reporting burden for the certification is estimated to average 35 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

DOE is not proposing to amend the certification or reporting requirements for consumer and residential-duty commercial water heaters in this SNOPR. Instead, DOE may consider proposals to amend the certification requirements and reporting for these products under a separate rulemaking regarding appliance and equipment certification. DOE will address changes to OMB Control Number 1910-1400 at that time, as necessary.

Notwithstanding any other provision of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA, unless that collection of information displays a currently valid OMB Control Number.

D. Review Under the National Environmental Policy Act of 1969

In this SNOPR, DOE proposes test procedure amendments that it expects will be used to develop and implement future energy conservation standards for consumer and residential-duty commercial water heaters. DOE has determined that this rule falls into a class of actions that are categorically excluded from review under the National Environmental Policy Act of 1969 (42 U.S.C. 4321 *et seq.*) and DOE's implementing regulations at 10 CFR part 1021. Specifically, DOE has determined that adopting test procedures for measuring energy efficiency of consumer products and industrial equipment is consistent with activities identified in 10 CFR part 1021, appendix A to subpart D, A5 and A6. Accordingly, neither an environmental assessment nor an environmental impact statement is required.

E. Review Under Executive Order 13132

Executive Order 13132, "Federalism," 64 FR 43255 (August 4, 1999), imposes certain requirements on agencies formulating and implementing policies or regulations that preempt State law or that have federalism implications. The Executive order requires agencies to examine the constitutional and statutory authority supporting any action that would limit the policymaking discretion of the States and to carefully assess the necessity for such actions. The Executive order also requires agencies to have an accountable process to ensure meaningful and timely input by State and local officials in the development of regulatory policies that have federalism implications. On March 14, 2000, DOE published a statement of policy describing the intergovernmental consultation process it will follow in the development of such regulations. 65 FR 13735. DOE has examined this proposed rule and has determined that it would not have a substantial direct effect on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. EPCA governs and prescribes Federal preemption of State regulations as to energy conservation for the products that are the subject of this proposed rule. States can petition DOE

for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297(d)) No further action is required by Executive Order 13132.

F. Review Under Executive Order 12988

Regarding the review of existing regulations and the promulgation of new regulations, section 3(a) of Executive Order 12988, "Civil Justice Reform," 61 FR 4729 (Feb. 7, 1996), imposes on Federal agencies the general duty to adhere to the following requirements: (1) eliminate drafting errors and ambiguity; (2) write regulations to minimize litigation; (3) provide a clear legal standard for affected conduct rather than a general standard, and (4) promote simplification and burden reduction. Section 3(b) of Executive Order 12988 specifically requires that Executive agencies make every reasonable effort to ensure that the regulation: (1) clearly specifies the preemptive effect, if any; (2) clearly specifies any effect on existing Federal law or regulation; (3) provides a clear legal standard for affected conduct while promoting simplification and burden reduction; (4) specifies the retroactive effect, if any; (5) adequately defines key terms, and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. Section 3(c) of Executive Order 12988 requires Executive agencies to review regulations in light of applicable standards in sections 3(a) and 3(b) to determine whether they are met or it is unreasonable to meet one or more of them. DOE has completed the required review and determined that, to the extent permitted by law, the proposed rule meets the relevant standards of Executive Order 12988.

G. Review Under the Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 ("UMRA") requires each Federal agency to assess the effects of Federal regulatory actions on State, local, and Tribal governments and the private sector. Pub. L. 104-4, sec. 201 (codified at 2 U.S.C. 1531). For a proposed regulatory action likely to result in a rule that may cause the expenditure by State, local, and

Tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a Federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a), (b)) The UMRA also requires a Federal agency to develop an effective process to permit timely input by elected officers of State, local, and Tribal governments on a proposed "significant intergovernmental mandate," and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect small governments. On March 18, 1997, DOE published a statement of policy on its process for intergovernmental consultation under UMRA. 62 FR 12820; also available at *www.energy.gov/gc/office-general-counsel*. DOE examined this proposed rule according to UMRA and its statement of policy and determined that the rule contains neither an intergovernmental mandate, nor a mandate that may result in the expenditure of $100 million or more in any year, so these requirements do not apply.

H. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 105-277) requires Federal agencies to issue a Family Policymaking Assessment for any rule that may affect family well-being. This proposed rule would not have any impact on the autonomy or integrity of the family as an institution. Accordingly, DOE has concluded that it is not necessary to prepare a Family Policymaking Assessment.

I. Review Under Executive Order 12630

DOE has determined, under Executive Order 12630, "Governmental Actions and Interference with Constitutionally Protected Property Rights," 53 FR 8859 (March 18, 1988),

that this proposed regulation would not result in any takings that might require compensation under the Fifth Amendment to the U.S. Constitution.

J. Review Under the Treasury and General Government Appropriations Act, 2001

Section 515 of the Treasury and General Government Appropriations Act, 2001 (44 U.S.C. 3516 note) provides for agencies to review most disseminations of information to the public under guidelines established by each agency pursuant to general guidelines issued by OMB. OMB's guidelines were published at 67 FR 8452 (Feb. 22, 2002), and DOE's guidelines were published at 67 FR 62446 (Oct. 7, 2002). Pursuant to OMB Memorandum M-19-15, Improving Implementation of the Information Quality Act (April 24, 2019), DOE published updated guidelines which are available at *www.energy.gov/sites/prod/files/2019/12/f70/DOE%20Final%20Updated%20IQA%20Guidelines%20Dec%202019.pdf*. DOE has reviewed this proposed rule under the OMB and DOE guidelines and has concluded that it is consistent with applicable policies in those guidelines.

K. Review Under Executive Order 13211

Executive Order 13211, "Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use," 66 FR 28355 (May 22, 2001), requires Federal agencies to prepare and submit to OMB, a Statement of Energy Effects for any proposed significant energy action. A "significant energy action" is defined as any action by an agency that promulgated or is expected to lead to promulgation of a final rule, and that: (1) is a significant regulatory action under Executive Order 12866, or any successor order; and (2) is likely to have a significant adverse effect on the supply, distribution, or use of energy; or (3) is designated by the Administrator of OIRA as a significant energy action. For any proposed significant energy action, the agency must give a detailed statement of any adverse effects on energy supply,

distribution, or use should the proposal be implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

The proposed regulatory action to amend the test procedure for measuring the energy efficiency of consumer and residential-duty commercial water heaters is not a significant regulatory action under Executive Order 12866. Moreover, it would not have a significant adverse effect on the supply, distribution, or use of energy, nor has it been designated as a significant energy action by the Administrator of OIRA. Therefore, it is not a significant energy action, and, accordingly, DOE has not prepared a Statement of Energy Effects.

L. Review Under Section 32 of the Federal Energy Administration Act of 1974

Under section 301 of the Department of Energy Organization Act (Pub. L. 95–91; 42 U.S.C. 7101), DOE must comply with section 32 of the Federal Energy Administration Act of 1974, as amended by the Federal Energy Administration Authorization Act of 1977. (15 U.S.C. 788; "FEAA") Section 32 essentially provides in relevant part that, where a proposed rule authorizes or requires use of commercial standards, the notice of proposed rulemaking must inform the public of the use and background of such standards. In addition, section 32(c) requires DOE to consult with the Attorney General and the Chairman of the Federal Trade Commission ("FTC") concerning the impact of the commercial or industry standards on competition.

As discussed in the January 11, 2022 NOPR, the proposed modifications to the test procedure for consumer and residential-duty commercial water heaters would incorporate testing methods contained in certain sections of the following commercial standards: ASHRAE 41.1-2020, ASTM D2156-09 (RA 2018), and a finalized version of ASHRAE 118.2. DOE has evaluated these standards and is unable to conclude whether they fully comply with the

requirements of section 32(b) of the FEAA (*i.e.*, whether they were developed in a manner that fully provides for public participation, comment, and review). DOE will consult with both the Attorney General and the Chairman of the FTC concerning the impact of these test procedures on competition, prior to prescribing a final rule.

V. Public Participation

DOE will accept comments, data, and information regarding this supplemental proposed rule no later than the date provided in the **DATES** section at the beginning of this SNOPR. Interested parties may submit comments, data, and other information using any of the methods described in the **ADDRESSES** section at the beginning of this document.

Submitting comments via www.regulations.gov. The *www.regulations.gov* webpage will require you to provide your name and contact information. Your contact information will be viewable to DOE Building Technologies staff only. Your contact information will not be publicly viewable except for your first and last names, organization name (if any), and submitter representative name (if any). If your comment is not processed properly because of technical difficulties, DOE will use this information to contact you. If DOE cannot read your comment due to technical difficulties and cannot contact you for clarification, DOE may not be able to consider your comment.

However, your contact information will be publicly viewable if you include it in the comment itself or in any documents attached to your comment. Any information that you do not want to be publicly viewable should not be included in your comment, nor in any document attached to your comment. Otherwise, persons viewing comments will see only first and last names, organization names, correspondence containing comments, and any documents submitted with the comments.

Do not submit to *www.regulations.gov* information for which disclosure is restricted by statute, such as trade secrets and commercial or financial information (hereinafter referred to as Confidential Business Information ("CBI")). Comments submitted through *www.regulations.gov* cannot be claimed as CBI. Comments received through the website will waive any CBI claims for the information submitted. For information on submitting CBI, see the Confidential Business Information section.

DOE processes submissions made through *www.regulations.gov* before posting. Normally, comments will be posted within a few days of being submitted. However, if large volumes of comments are being processed simultaneously, your comment may not be viewable for up to several weeks. Please keep the comment tracking number that *www.regulations.gov* provides after you have successfully uploaded your comment.

Submitting comments via email. Comments and documents submitted via email also will be posted to *www.regulations.gov*. If you do not want your personal contact information to be publicly viewable, do not include it in your comment or any accompanying documents. Instead, provide your contact information in a cover letter. Include your first and last names, email address, telephone number, and optional mailing address. With this instruction followed, the cover letter will not be publicly viewable as long as it does not include any comments.

Include contact information each time you submit comments, data, documents, and other information to DOE. No telefacsimiles (faxes) will be accepted.

Comments, data, and other information submitted to DOE electronically should be provided in PDF (preferred), Microsoft Word or Excel, WordPerfect, or text (ASCII) file format. Provide documents that are not secured, written in English, and free of any defects or viruses.

Documents should not contain special characters or any form of encryption, and, if possible, they should carry the electronic signature of the author.

Campaign form letters. Please submit campaign form letters by the originating organization in batches of between 50 to 500 form letters per PDF or as one form letter with a list of supporters' names compiled into one or more PDFs. This reduces comment processing and posting time.

Confidential Business Information. Pursuant to 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit via email two well-marked copies: one copy of the document marked "confidential" including all the information believed to be confidential, and one copy of the document marked "non-confidential" with the information believed to be confidential deleted. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

It is DOE's policy that all comments may be included in the public docket, without change and as received, including any personal information provided in the comments (except information deemed to be exempt from public disclosure).

VI. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this supplemental notice of proposed rulemaking and request for comment.

List of Subjects in 10 CFR Part 430

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Imports, Intergovernmental relations, Reporting and recordkeeping requirements, Small businesses.

Signing Authority

This document of the Department of Energy was signed on July 1, 2022, by Kelly J. Speakes-Backman, Principal Deputy Assistant Secretary for Energy Efficiency and Renewable Energy, pursuant to delegated authority from the Secretary of Energy. That document with the original signature and date is maintained by DOE. For administrative purposes only, and in compliance with requirements of the Office of the Federal Register, the undersigned DOE Federal Register Liaison Officer has been authorized to sign and submit the document in electronic format for publication, as an official document of the Department of Energy. This administrative process in no way alters the legal effect of this document upon publication in the *Federal Register*.

Signed in Washington, DC, on July 6, 2022.

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Treena V. Garrett
Federal Register Liaison Officer,
U.S. Department of Energy

For the reasons stated in the preamble, DOE is proposing to amend part 430 of Chapter II of Title 10, Code of Federal Regulations, as set forth below:

PART 430 -- ENERGY CONSERVATION PROGRAM FOR CONSUMER PRODUCTS

1. The authority citation for part 430 continues to read as follows:

Authority: 42 U.S.C. 6291-6309; 28 U.S.C. 2461 note.

2. Appendix E to subpart B of part 430 is amended by:

a. Revising the note at the beginning of the appendix;

b. Revising section 1;

c. Adding new sections 2.8, 4.10;

d. Revising sections 5.1, 5.4.2;

e. Adding sections 5.6, 6.3.1.1;

f. Revising section 6.3.9; and

g. Adding new section 6.5;

The revisions and additions read as follows:

APPENDIX E TO SUBPART B OF PART 430—UNIFORM TEST METHOD FOR MEASURING THE ENERGY CONSUMPTION OF WATER HEATERS

Note: Prior to [*date 180 days after date of publication of the final rule in the Federal Register*], representations with respect to the energy use or efficiency of consumer water heaters and residential-duty commercial water heaters covered by this test method, including compliance certifications, must be based on testing conducted in accordance with either this appendix as it now appears or appendix E as it appeared at 10 CFR part 430, subpart B revised as of January 1, 2021.

On and after [*date 180 days after date of publication of the final rule in the Federal Register*], representations with respect to energy use or efficiency of consumer water heaters and residential-duty commercial water heaters covered by this test method, including compliance certifications, must be based on testing conducted in accordance with this appendix.

In addition, water heaters subject to section 5.1.2 of this appendix may optionally apply the requirements in section 5.1.1 of this appendix in lieu of the requirements in section 5.1.2 of this appendix until the compliance date of a final rule reviewing potential amended energy conservation standards for these products published after [*date of publication of the final rule in the Federal Register*].

1. Definitions.

1.1. *Cut-in* means the time when or water temperature at which a water heater control or thermostat acts to increase the energy or fuel input to the heating elements, compressor, or burner.

1.2. *Cut-out* means the time when or water temperature at which a water heater control or thermostat acts to reduce to a minimum the energy or fuel input to the heating elements, compressor, or burner.

1.3. *Demand-response water heater* means a storage-type water heater that –

(1) Has integrated communications hardware and additional hardware and software required to enable connected functionality with a utility or third party, which dispatches signals with demand response instructions and/or price signals to the product and receives messages from the demand-response water heater;

(2) Meets the communication and equipment standards for Consumer Technology Association Standard 2045-B (CTA-2045-B);

(3) Automatically heats the stored water above the delivery temperature setpoint only in response to instructions received from a utility or third party.

1.4. *Design Power Rating* means the power rating or input rate that a water heater manufacturer assigns to a particular design of water heater and that is included on the nameplate of the water heater, expressed in kilowatts or Btu (kJ) per hour as appropriate. For modulating water heaters, the design power rating is the maximum power rating or input rate that is specified by the manufacturer on the nameplate of the water heater.

1.5. *Draw Cluster* means a collection of water draws initiated during the 24-hour simulated-use test during which no successive draws are separated by more than 2 hours.

1.6. *First-Hour Rating* means an estimate of the maximum volume of "hot" water that a non-flow activated water heater can supply within an hour that begins with the water heater fully heated (*i.e.*, with all thermostats satisfied).

1.7. *Flow-Activated* describes an operational scheme in which a water heater initiates and terminates heating based on sensing flow.

1.8. *Heat Trap* means a device that can be integrally connected or independently attached to the hot and/or cold water pipe connections of a water heater such that the device will develop a thermal or mechanical seal to minimize the recirculation of water due to thermal convection between the water heater tank and its connecting pipes.

1.9. *Maximum GPM (L/min) Rating* means the maximum gallons per minute (liters per minute) of hot water that can be supplied by flow-activated water heater when tested in accordance with section 5.3.2 of this appendix.

1.10. *Modulating Water Heater* means a water heater that can automatically vary its power or input rate from the minimum to the maximum power or input rate specified on the nameplate of the water heater by the manufacturer.

1.11. *Rated Storage Volume* means the water storage capacity of a water heater, in gallons (liters), as certified by the manufacturer pursuant to 10 CFR part 429.

1.12. *Recovery Efficiency* means the ratio of energy delivered to the water to the energy content of the fuel consumed by the water heater.

1.13. *Recovery Period* means the time when the main burner of a water heater with a rated storage volume greater than or equal to 2 gallons is raising the temperature of the stored water.

1.14. *Split-system heat pump water heater* means a heat pump-type water heater with an indoor storage tank and outdoor heat pump component.

1.15. *Standby* means the time, in hours, during which water is not being withdrawn from the water heater.

1.16. *Symbol Usage*. The following identity relationships are provided to help clarify the symbology used throughout this procedure:

C_p—specific heat of water

E_{annual}—annual energy consumption of a water heater

$E_{annual,e}$—annual electrical energy consumption of a water heater

$E_{annual,f}$—annual fossil-fuel energy consumption of a water heater

E_X—energy efficiency of a heat pump-type water heater when the 24-hour simulated use test is optionally conducted at any of the additional air temperature conditions as specified in section 2.8 of this appendix, where the subscript "X" corresponds to the dry-bulb temperature at which the test is conducted.

F_{hr}—first-hour rating of a non-flow activated water heater

F_{max}—maximum GPM (L/min) rating of a flow-activated water heater

i—a subscript to indicate the draw number during a test

k_V—storage tank volume scaling ratio for water heaters with a rated storage volume greater than or equal to 2 gallons

$M_{del,i}$—mass of water removed during the ith draw of the 24-hour simulated-use test

$M_{in,i}$—mass of water entering the water heater during the ith draw of the 24-hour simulated-use test

$M^*_{del,i}$—for non-flow activated water heaters, mass of water removed during the ith draw during the first-hour rating test

$M^*_{in,i}$—for non-flow activated water heaters, mass of water entering the water heater during the *i*th draw during the first-hour rating test

$M_{del,10m}$—for flow-activated water heaters, mass of water removed continuously during the maximum GPM (L/min) rating test

$M_{in,10m}$—for flow-activated water heaters, mass of water entering the water heater continuously during the maximum GPM (L/min) rating test

n—for non-flow activated water heaters, total number of draws during the first-hour rating test

N—total number of draws during the 24-hour simulated-use test

N_r— number of draws from the start of the 24-hour simulated-use test to the end to the first recovery period as described in section 5.4.2 of this appendix

Q—total fossil fuel and/or electric energy consumed during the entire 24-hour simulated-use test

Q_d—daily water heating energy consumption adjusted for net change in internal energy

Q_{da}—Q_d with adjustment for variation of tank to ambient air temperature difference from nominal value

Q_{dm}—overall adjusted daily water heating energy consumption including Q_{da} and Q_{HWD}

Q_e—total electrical energy used during the 24-hour simulated-use test

Q_f—total fossil fuel energy used by the water heater during the 24-hour simulated-use test

Q_{hr}—hourly standby losses of a water heater with a rated storage volume greater than or equal to 2 gallons

Q_{HW}—daily energy consumption to heat water at the measured average temperature rise across the water heater

$Q_{HW,67\ °F}$—daily energy consumption to heat quantity of water removed during test over a temperature rise of 67 °F (37.3 °C)

Q_{HWD}—adjustment to daily energy consumption, Q_{HW}, due to variation of the temperature rise across the water heater not equal to the nominal value of 67 °F (37.3 °C)

Q_r—energy consumption of water heater from the beginning of the test to the end of the first recovery period

Q_{stby}—total energy consumed during the standby time interval $\tau_{stby,1,}$ as determined in section 5.4.2 of this appendix

$Q_{su,0}$— cumulative energy consumption, including all fossil fuel and electrical energy use, of the water heater from the start of the 24-hour simulated-use test to the start of the standby period as determined in section 5.4.2 of this appendix

$Q_{su,f}$—cumulative energy consumption, including all fossil fuel and electrical energy use, of the water heater from the start of the 24-hour simulated-use test to the end of the standby period as determined in section 5.4.2 of this appendix

$\bar{T}_0$—mean tank temperature at the beginning of the 24-hour simulated-use test as determined in section 5.4.2 of this appendix

$\bar{T}_{24}$—mean tank temperature at the end of the 24-hour simulated-use test as determined in section 5.4.2 of this appendix

$\bar{T}_{a,stby}$—average ambient air temperature during all standby periods of the 24-hour simulated-use test as determined in section 5.4.2 of this appendix

$\bar{T}_{a,stby,1}$—overall average ambient temperature between the start and end of the standby period as determined in section 5.4.2 of this appendix

$\bar{T}_{t,stby,1}$— overall average mean tank temperature between the start and end of the standby period as determined in section 5.4.2 of this appendix

$\bar{T}_{del}$—for flow-activated water heaters, average outlet water temperature during the maximum GPM (L/min) rating test

$\bar{T}_{del,i}$—average outlet water temperature during the *i*th draw of the 24-hour simulated-use test

$\bar{T}_{in}$—for flow-activated water heaters, average inlet water temperature during the maximum GPM (L/min) rating test

$\bar{T}_{st}$—for water heaters which cannot have internal tank temperature directly measured, estimated average internal storage tank temperature

T_p—for water heaters which cannot have internal tank temperature directly measured, average of the inlet and the outlet water temperatures at the end of the period defined by τ_p

$\overline{T}_{in,p}$—for water heaters which cannot have internal tank temperature directly measured, average of the inlet water temperatures

$\overline{T}_{out,p}$—for water heaters which cannot have internal tank temperature directly measured, average of the outlet water temperatures

$\overline{T}_{in,i}$—average inlet water temperature during the *i*th draw of the 24-hour simulated-use test

$\overline{T}_{max,1}$—maximum measured mean tank temperature after the first recovery period of the 24-hour simulated-use test as determined in section 5.4.2 of this appendix

$\overline{T}_{su,0}$—maximum measured mean tank temperature at the beginning of the standby period as determined in section 5.4.2 of this appendix

$\overline{T}_{su,f}$—measured mean tank temperature at the end of the standby period as determined in section 5.4.2 of this appendix

$\overline{T}^{*}_{del,i}$—for non-flow activated water heaters, average outlet water temperature during the *i*th draw (i = 1 to n) of the first-hour rating test

$\overline{T}^{*}_{max,i}$—for non-flow activated water heaters, maximum outlet water temperature observed during the *i*th draw (i = 1 to n) of the first-hour rating test

$T^*_{min,i}$—for non-flow activated water heaters, minimum outlet water temperature to terminate the *i*th draw (i = 1 to n) of the first-hour rating test

UA—standby loss coefficient of a water heater with a rated storage volume greater than or equal to 2 gallons

UEF—uniform energy factor of a water heater

V—the volume of hot water drawn during the applicable draw pattern

$V_{del,i}$—volume of water removed during the *i*th draw (i = 1 to N) of the 24-hour simulated-use test

$V_{in,i}$—volume of water entering the water heater during the *i*th draw (i = 1 to N) of the 24-hour simulated-use test

$V^*_{del,i}$—for non-flow activated water heaters, volume of water removed during the *i*th draw (i = 1 to n) of the first-hour rating test

$V^*_{in,i}$—for non-flow activated water heaters, volume of water entering the water heater during the *i*th draw (i = 1 to n) of the first-hour rating test

$V_{del,10m}$—for flow-activated water heaters, volume of water removed during the maximum GPM (L/min) rating test

$V_{in,10m}$—for flow-activated water heaters, volume of water entering the water heater during the maximum GPM (L/min) rating test

V_{st}—measured storage volume of the storage tank for water heaters with a rated storage volume greater than or equal to 2 gallons

V_{eff}—effective storage volume of water heaters with a rated storage volume greater than or equal to 2 gallons

$v_{out,p}$—for water heaters which cannot have internal tank temperature directly measured, average flow rate

W_f—weight of storage tank when completely filled with water for water heaters with a rated storage volume greater than or equal to 2 gallons

W_t—tare weight of storage tank when completely empty of water for water heaters with a rated storage volume greater than or equal to 2 gallons

η_r—recovery efficiency

ρ—density of water

τ_p—for water heaters which cannot have internal tank temperature directly measured, duration of the temperature measurement period, determined by the length of time taken for the outlet water temperature to be within 2 °F of the inlet water temperature for 15 consecutive seconds (including the 15-second stabilization period)

$\tau_{stby,1}$—elapsed time between the start and end of the standby period as determined in section 5.4.2 of this appendix

$\tau_{stby,2}$—overall time of standby periods when no water is withdrawn during the 24-hour simulated-use test as determined in section 5.4.2 of this appendix

1.17. *Temperature Controller* means a device that is available to the user to adjust the temperature of the water inside a water heater that stores heated water or the outlet water temperature.

1.18. *Uniform Energy Factor* means the measure of water heater overall efficiency.

1.19. *Water Heater Requiring a Storage Tank* means a water heater without a storage tank specified or supplied by the manufacturer that cannot meet the requirements of sections 2 and 5 of this appendix without the use of a storage water heater or unfired hot water storage tank.

2. * * *

2.8 *Optional Test Conditions (Heat Pump-Type Water Heaters).*

The following test conditions may be used for optional representations of E_X for heat pump-type water heaters. When conducting a 24-hour simulated use test to determine E_X, the test conditions in section 2.1 and sections 2.4 through 2.7 apply. The ambient air temperature and humidity conditions in section 2.2 and the supply water temperature in section 2.3 are replaced with the air temperature, humidity, and supply water temperature conditions as shown in the following table. Testing may optionally be performed at any or all of the conditions in the table.

Heat Pump Type	**Metric**	**Outdoor Air Conditions**		**Indoor Air Conditions**		**Supply Water Temperature**
		Dry-Bulb Temperature	Relative Humidity	Dry-Bulb Temperature	Relative Humidity	
Split-System	E_5	5.0 °F	30%	67.5 °F	50%	42.0 °F

	E_{34}	34.0 °F	72%			47.0 °F
	E_{95}	95.0 °F	25%			67.0 °F
Integrated or Heat Pump-Only	E_{50}	N/A	N/A	50.0 °F	58%	50.0 °F
	E_{95}	N/A	N/A	95.0 °F	40%	67.0 °F

* * * * *

4. * * *

4.10 *Storage Tank Requirement for Circulating Water Heaters.*

When testing a gas-fired, oil-fired, or electric resistance circulating water heater (*i.e.*, any circulating water heater that does not use a heat pump), the tank to be used for testing shall be an unfired hot water storage tank having a certified volume between 80 and 120 gallons (364-546 liters) that meets but does not exceed the minimum energy conservation standards required according to 10 CFR 431.110. When testing a heat pump circulating water heater, the tank to be used for testing shall be an electric storage water heater that uses only electric resistance elements for heating, has a measured volume of 40 gallons (± 4 gallons), has a First-Hour Rating greater than or equal to 51 gallons and less than 75 gallons resulting in classification under the medium draw pattern, and has a rated UEF equal to the minimum UEF standard specified at § 430.32(d), rounded to the nearest 0.01. In addition, the water heater used for testing shall not be capable of "over-heating" the stored water, as determined by $\overline{T}_{max,1}$ (maximum measured mean tank temperature after the first recovery period of the 24-hour simulated-use test) being less than or equal to $\overline{T}_{del,2}$ (average outlet water temperature during the 2nd draw of the 24-hour simulated-use test).

5. * * *

5.1 *Operational Mode Selection.* For water heaters that allow for multiple user-selected operational modes, all procedures specified in this appendix shall be carried out with the water heater in the same operational mode (*i.e.,* only one mode). Water heaters subject to section 5.1.2 of this appendix may optionally apply the requirements in section 5.1.1 in lieu of the requirements in section 5.1.2 of this appendix until the compliance date of a final rule reviewing potential amended energy conservation standards for these products published after [*date of publication of the test procedure final rule in the Federal Register*]

5.1.1 *Water Heaters Without Storage Tank Over-heating Capability.* If a non-flow-activated water heater does not have any user-selectable operational modes where the mean temperature of the storage tank can be maintained at a temperature higher than the delivery setpoint temperature (*e.g.*, by use of a mixing valve), the instructions in this section apply. The operational mode shall be the default mode (or similarly named, suggested mode for normal operation) as defined by the manufacturer in the I&O manual for giving selection guidance to the consumer. For heat pump water heaters, if a default mode is not defined in the product literature, each test shall be conducted under an operational mode in which both the heat pump and any electric resistance backup heating element(s) are activated by the unit's control scheme, and which can achieve the internal storage tank temperature specified in this test procedure; if multiple operational modes meet these criteria, the water heater shall be tested under the most energy-intensive mode. If no default mode is specified and the unit does not offer an operational mode that utilizes both the heat pump and the electric resistance backup heating element(s), the first-hour rating test and the 24-hour simulated-use test shall be tested in heat-pump-only mode. For other types of water heaters where a default mode is not specified, test the unit in all modes and rate the unit using the results of the most energy-intensive mode.

5.1.2 *Water Heaters With Storage Tank Over-heating Capability.* If a non-flow-activated water heater that is not a demand-response water heater (as defined in section 1.3 of this appendix) has a user-selectable operational mode where the mean temperature of the storage tank can be maintained at a temperature higher than the delivery setpoint temperature (*e.g.*, by use of a mixing valve), set the unit to maintain the highest mean tank temperature possible while delivering water at 125 °F ±5 °F. Maintain this setting throughout the entirety of the test.

* * * * *

5.4 * * *

5.4.2 *Test Sequence for Water Heater With Rated Storage Volume Greater Than or Equal to 2 Gallons*.

If the water heater is turned off, fill the water heater with supply water at the temperature specified in section 2.3 of this appendix and maintain supply water pressure as described in section 2.6 of this appendix. Turn on the water heater and associated heat pump unit, if present. If turned on in this fashion, the soak-in period described in section 5.2.4 of this appendix shall be implemented. If the water heater has undergone a first-hour rating test prior to conduct of the 24-hour simulated-use test, allow the water heater to fully recover after completion of that test such that the main burner, heating elements, or heat pump compressor of the water heater are no longer raising the temperature of the stored water. In all cases, the water heater shall sit idle for 1 hour prior to the start of the 24-hour test; during which time no water is drawn from the unit, and there is no energy input to the main heating elements, heat pump compressor, and/or burners.

For water heaters that can have their internal storage tank temperature measured directly, perform testing in accordance with the instructions in section 5.4.2.1 of this appendix. For water

heaters that cannot have their internal tank temperatures measured, perform testing in accordance with the instructions in section 5.4.2.2. of this appendix.

5.4.2.1 *Water Heaters which Can Have Internal Storage Tank Temperature Measured Directly.*

After the 1-hour period specified in section 5.4.2 of this appendix, the 24-hour simulated-use test will begin. One minute prior to the start of the 24-hour test simulated-use test, record the mean tank temperature (T_0).

At the start of the 24-hour simulated-use test, record the electrical and/or fuel measurement readings, as appropriate. Begin the 24-hour simulated-use test by withdrawing the volume specified in the appropriate table in section 5.5 of this appendix (*i.e.*, Table III.1, Table III.2, Table III.3, or Table III.4, depending on the first-hour rating or maximum GPM rating) for the first draw at the flow rate specified in the applicable table. Record the time when this first draw is initiated and assign it as the test elapsed time (τ) of zero (0). Record the average storage tank and ambient temperature every minute throughout the 24-hour simulated-use test. At the elapsed times specified in the applicable draw pattern table in section 5.5 of this appendix for a particular draw pattern, initiate additional draws pursuant to the draw pattern, removing the volume of hot water at the prescribed flow rate specified by the table. The maximum allowable deviation from the specified volume of water removed for any single draw taken at a nominal flow rate of 1.0 GPM or 1.7 GPM is ± 0.1 gallons (± 0.4 liters). The maximum allowable deviation from the specified volume of water removed for any single draw taken at a nominal flow rate of 3.0 GPM is ± 0.25 gallons (0.9 liters). The quantity of water withdrawn during the last draw shall be increased or decreased as necessary such that the total volume of water withdrawn equals the prescribed daily amount for that draw pattern ±1.0 gallon (±3.8 liters). If

this adjustment to the volume drawn during the last draw results in no draw taking place, the test is considered invalid.

All draws during the 24-hour simulated-use test shall be made at the flow rates specified in the applicable draw pattern table in section 5.5 of this appendix, within a tolerance of ±0.25 gallons per minute (±0.9 liters per minute). Measurements of the inlet and outlet temperatures shall be made 15 seconds after the draw is initiated and at every subsequent 3-second interval throughout the duration of each draw. Calculate and record the mean of the hot water discharge temperature and the cold water inlet temperature for each draw $T_{del,i}$ and $T_{in,i}$). Determine and record the net mass or volume removed (M_i or V_i), as appropriate, after each draw.

The first recovery period is the time from the start of the 24-hour simulated-use test and continues during the temperature rise of the stored water until the first cut-out; if the cut-out occurs during a subsequent draw, the first recovery period includes the time until the draw of water from the tank stops. If, after the first cut-out occurs but during a subsequent draw, a subsequent cut-in occurs prior to the draw completion, the first recovery period includes the time until the subsequent cut-out occurs, prior to another draw. The first recovery period may continue until a cut-out occurs when water is not being removed from the water heater or a cut-out occurs during a draw and the water heater does not cut-in prior to the end of the draw.

At the end of the first recovery period, record the maximum mean tank temperature observed after cut-out ($T_{max,1}$). At the end of the first recovery period, record the total energy consumed by the water heater from the beginning of the test (Q_r), including all fossil fuel and/or electrical energy use, from the main heat source and auxiliary equipment including, but not limited to, burner(s), resistive elements(s), compressor, fan, controls, pump, etc., as applicable.

The start of the portion of the test during which the standby loss coefficient is determined depends upon whether the unit has fully recovered from the first draw cluster. If a recovery is occurring at or within five minutes after the end of the final draw in the first draw cluster, as identified in the applicable draw pattern table in section 5.5 of this appendix, then the standby period starts when a maximum mean tank temperature is observed starting five minutes after the end of the recovery period that follows that draw. If a recovery does not occur at or within five minutes after the end of the final draw in the first draw cluster, as identified in the applicable draw pattern table in section 5.5 of this appendix, then the standby period starts five minutes after the end of that draw. Determine and record the total electrical energy and/or fossil fuel consumed from the beginning of the test to the start of the standby period ($Q_{su,0}$).

In preparation for determining the energy consumed during standby, record the reading given on the electrical energy (watt-hour) meter, the gas meter, and/or the scale used to determine oil consumption, as appropriate. Record the mean tank temperature at the start of the standby period ($T_{su,0}$). At 1-minute intervals, record ambient temperature, the electric and/or fuel instrument readings and the mean tank temperature until the next draw is initiated. The end of the standby period is when the final mean tank temperature is recorded, as described. Just prior to initiation of the next draw, record the mean tank temperature ($T_{su,f}$). If the water heater is undergoing recovery when the next draw is initiated, record the mean tank temperature ($T_{su,f}$) at the minute prior to the start of the recovery. Determine the total electrical energy and/or fossil fuel energy consumption from the beginning of the test to the end of the standby period ($Q_{su,f}$). Record the time interval between the start of the standby period and the end of the standby period ($\tau_{stby,1}$).

Following the final draw of the prescribed draw pattern and subsequent recovery, allow the water heater to remain in the standby mode until exactly 24 hours have elapsed since the start

of the 24-hour simulated-use test (*i.e.*, since $\tau = 0$). During the last hour of the 24-hour simulated-use test (*i.e.*, hour 23 of the 24-hour simulated-use test), power to the main burner, heating element, or compressor shall be disabled. At 24 hours, record the reading given by the gas meter, oil meter, and/or the electrical energy meter as appropriate. Determine the fossil fuel and/or electrical energy consumed during the entire 24-hour simulated-use test and designate the quantity as Q.

In the event that the recovery period continues from the end of the last draw of the first draw cluster until the subsequent draw, the standby period will start after the end of the first recovery period after the last draw of the 24-hour simulated-use test, when the temperature reaches the maximum mean tank temperature, though no sooner than five minutes after the end of this recovery period. The standby period shall last eight hours, so testing may extend beyond the 24-hour duration of the 24-hour simulated-use test. Determine and record the total electrical energy and/or fossil fuel consumed from the beginning of the 24-hour simulated-use test to the start of the 8-hour standby period ($Q_{su,0}$). In preparation for determining the energy consumed during standby, record the reading(s) given on the electrical energy (watt-hour) meter, the gas meter, and/or the scale used to determine oil consumption, as appropriate. Record the mean tank temperature at the start of the standby period ($T_{su,0}$). Record the mean tank temperature, the ambient temperature, and the electric and/or fuel instrument readings at 1-minute intervals until the end of the 8-hour period. Record the mean tank temperature at the end of the 8-hour standby period ($T_{su,f}$). If the water heater is undergoing recovery at the end of the standby period, record the mean tank temperature ($T_{su,f}$) at the minute prior to the start of the recovery, which will mark the end of the standby period. Determine the total electrical energy and/or fossil fuel energy consumption from the beginning of the test to the end of the standby period ($Q_{su,f}$). Record the time interval between the start of the standby period and the end of the standby period as $\tau_{stby,1}$. Record the average ambient temperature from the start of the standby period to the end of the

standby period ($T_{a,stby,1}$). Record the average mean tank temperature from the start of the standby period to the end of the standby period ($T_{t,stby,1}$).

If the standby period occurred at the end of the first recovery period after the last draw of the 24-hour simulated-use test, allow the water heater to remain in the standby mode until exactly 24 hours have elapsed since the start of the 24-hour simulated-use test (*i.e.*, since $\tau = 0$) or the end of the standby period, whichever is longer. At 24 hours, record the mean tank temperature (T_{24}) and the reading given by the gas meter, oil meter, and/or the electrical energy meter as appropriate. If the water heater is undergoing a recovery at 24 hours, record the reading given by the gas meter, oil meter, and/or electrical energy meter, as appropriate, and the mean tank temperature (T_{24}) at the minute prior to the start of the recovery. Determine the fossil fuel and/or electrical energy consumed during the 24 hours and designate the quantity as Q.

Record the time during which water is not being withdrawn from the water heater during the entire 24-hour period ($\tau_{stby,2}$). When the standby period occurs after the last draw of the 24-hour simulated-use test, the test may extend past hour 24. When this occurs, the measurements taken after hour 24 apply only to the calculations of the standby loss coefficient. All other measurements during the time between hour 23 and hour 24 remain the same.

5.4.2.2 *Water Heaters which Cannot Have Internal Storage Tank Temperature Measured Directly.*

After the water heater has undergone a 1-hour idle period (as described in section 5.4.2 of this appendix), deactivate the burner, compressor, or heating element(s).

Remove the water from the storage tank by performing a continuous draw at a flow rate of 3.0 GPM (11.4 L/min) ± 0.25 GPM (0.9 L/min) until the outlet water temperature is within ±2

°F (±1.1 °C) of the inlet water temperature for 15 consecutive seconds. While removing the hot water, measure the inlet and outlet temperature beginning 15 seconds after initiating the draw and at 3-second intervals thereafter until the outlet condition has stabilized. Determine the mean tank temperature using section 6.3.9 of this appendix and assign this value of $\bar{T}_{st}$ for $\bar{T}_0$, $\bar{T}_{max,1}$, and $\bar{T}_{su,0}$.

After completing the draw, reactivate the burner, compressor, or heating elements(s) and allow the unit to fully recover such that the main burner, heating elements, or heat pump compressor is no longer raising the temperature of the stored water. Let the water heater sit idle again for 1 hour prior to beginning the 24-hour test, during which time no water shall be drawn from the unit, and there shall be no energy input to the main heating elements. After the 1-hour period, the 24-hour simulated-use test will begin.

At the start of the 24-hour simulated-use test, record the electrical and/or fuel measurement readings, as appropriate. Begin the 24-hour simulated-use test by withdrawing the volume specified in the appropriate table in section 5.5 of this appendix (*i.e.*, Table III.1, Table III.2, Table III.3, or Table III.4, depending on the first-hour rating or maximum GPM rating) for the first draw at the flow rate specified in the applicable table. Record the time when this first draw is initiated and assign it as the test elapsed time (τ) of zero (0). Record the average ambient temperature every minute throughout the 24-hour simulated-use test. At the elapsed times specified in the applicable draw pattern table in section 5.5 of this appendix for a particular draw pattern, initiate additional draws pursuant to the draw pattern, removing the volume of hot water at the prescribed flow rate specified by the table. The maximum allowable deviation from the specified volume of water removed for any single draw taken at a nominal flow rate of 1.0 GPM or 1.7 GPM is ± 0.1 gallons (± 0.4 liters). The maximum allowable deviation from the specified volume of water removed for any single draw taken at a nominal flow rate of 3.0 GPM is ± 0.25

gallons (0.9 liters). The quantity of water withdrawn during the last draw shall be increased or decreased as necessary such that the total volume of water withdrawn equals the prescribed daily amount for that draw pattern ± 1.0 gallon (± 3.8 liters). If this adjustment to the volume drawn during the last draw results in no draw taking place, the test is considered invalid.

All draws during the 24-hour simulated-use test shall be made at the flow rates specified in the applicable draw pattern table in section 5.5 of this appendix, within a tolerance of ±0.25 gallons per minute (±0.9 liters per minute). Measurements of the inlet and outlet temperatures shall be made 15 seconds after the draw is initiated and at every subsequent 3-second interval throughout the duration of each draw. Calculate and record the mean of the hot water discharge temperature and the cold water inlet temperature for each draw $T_{del,i}$ and $T_{in,i}$). Determine and record the net mass or volume removed (M_i or V_i), as appropriate, after each draw.

The first recovery period is the time from the start of the 24-hour simulated-use test and continues until the first cut-out; if the cut-out occurs during a subsequent draw, the first recovery period includes the time until the draw of water from the tank stops. If, after the first cut-out occurs but during a subsequent draw, a subsequent cut-in occurs prior to the draw completion, the first recovery period includes the time until the subsequent cut-out occurs, prior to another draw. The first recovery period may continue until a cut-out occurs when water is not being removed from the water heater or a cut-out occurs during a draw and the water heater does not cut-in prior to the end of the draw.

At the end of the first recovery period, record the total energy consumed by the water heater from the beginning of the test (Q_r), including all fossil fuel and/or electrical energy use, from the main heat source and auxiliary equipment including, but not limited to, burner(s), resistive elements(s), compressor, fan, controls, pump, etc., as applicable.

The standby period begins at five minutes after the first time a recovery ends following last draw of the simulated-use test and shall continue for 8 hours. At the end of the 8-hour standby period, record the total amount of time elapsed since the start of the 24-hour simulated-use test (*i.e.*, since $\tau = 0$).

Determine and record the total electrical energy and/or fossil fuel consumed from the beginning of the 24-hour simulated-use test to the start of the 8-hour standby period ($Q_{su,0}$). In preparation for determining the energy consumed during standby, record the reading(s) given on the electrical energy (watt-hour) meter, the gas meter, and/or the scale used to determine oil consumption, as appropriate. Record the ambient temperature and the electric and/or fuel instrument readings at 1-minute intervals until the end of the 8-hour period. At the 8-hour mark, deactivate the water heater and before drawing water from the tank. Remove water from the storage tank by performing a continuous draw at a flow rate of 3.0 GPM (11.4 L/min) ± 0.25 GPM (0.9 L/min) until the outlet water temperature is within ±2 °F (±1.1 °C) of the inlet water temperature for 15 consecutive seconds. While removing the hot water, measure the inlet and outlet temperature beginning 15 seconds after initiating the draw and at 3-second intervals thereafter until the outlet condition has stabilized. Determine the mean tank temperature using section 6.3.9 of this appendix and assign this value of $\bar{T}_{st}$ for $\bar{T}_{su,f}$ and $\bar{T}_{24}$.

Determine the total electrical energy and/or fossil fuel energy consumption from the beginning of the test to the end of the standby period ($Q_{su,f}$). Record the time interval between the start of the standby period and the end of the standby period as $\tau_{stby,1}$. Record the average ambient temperature from the start of the standby period to the end of the standby period ($T_{a,stby,1}$). The average mean tank temperature from the start of the standby period to the end of the standby period ($T_{t,stby,1}$) shall be the average of $T_{su,0}$ and $T_{su,f.}$

5.4.3 *Test Sequence for Water Heaters with Rated Storage Volume Less Than 2 Gallons.*

Establish normal operation with the discharge water temperature at 125 °F ±5 °F (51.7 °C ±2.8 °C) and set the flow rate as determined in section 5.2 of this appendix. Prior to commencement of the 24-hour simulated-use test, the unit shall remain in an idle state in which controls are active but no water is drawn through the unit for a period of one hour. With no draw occurring, record the reading given by the gas meter and/or the electrical energy meter as appropriate. Begin the 24-hour simulated-use test by withdrawing the volume specified in Tables III.1 through III.4 of section 5.5 of this appendix for the first draw at the flow rate specified. Record the time when this first draw is initiated and designate it as an elapsed time, τ, of 0. At the elapsed times specified in Tables III.1 through III.4 for a particular draw pattern, initiate additional draws, removing the volume of hot water at the prescribed flow rate specified in Tables III.1 through III.4. The maximum allowable deviation from the specified volume of water removed for any single draw taken at a nominal flow rate less than or equal to 1.7 GPM (6.4 L/min) is ±0.1 gallons (±0.4 liters). The maximum allowable deviation from the specified volume of water removed for any single draw taken at a nominal flow rate of 3.0 GPM (11.4 L/min) is ±0.25 gallons (0.9 liters). The quantity of water drawn during the final draw shall be increased or decreased as necessary such that the total volume of water withdrawn equals the prescribed daily amount for that draw pattern ±1.0 gallon (±3.8 liters). If this adjustment to the volume drawn in the last draw results in no draw taking place, the test is considered invalid.

All draws during the 24-hour simulated-use test shall be made at the flow rates specified in the applicable draw pattern table in section 5.5 of this appendix within a tolerance of ± 0.25 gallons per minute (±0.9 liters per minute) unless the unit being tested has a rated Max GPM of less than 1 gallon per minute, in which case the tolerance shall be ± 25% of the rated Max GPM. Measurements of the inlet and outlet water temperatures shall be made 15 seconds after the draw

is initiated and at every 3-second interval thereafter throughout the duration of the draw. Calculate the mean of the hot water discharge temperature and the cold water inlet temperature for each draw. Record the mass of the withdrawn water or the water meter reading, as appropriate, after each draw. At the end of the first recovery period following the first draw, determine and record the fossil fuel and/or electrical energy consumed, Q_r. Following the final draw and subsequent recovery, allow the water heater to remain in the standby mode until exactly 24 hours have elapsed since the start of the test (*i.e.,* since $\tau = 0$). At 24 hours, record the reading given by the gas meter, oil meter, and/or the electrical energy meter, as appropriate. Determine the fossil fuel and/or electrical energy consumed during the entire 24-hour simulated-use test and designate the quantity as Q.

* * * * *

5.6 *Optional Tests (Heat Pump-Type Water Heaters).*

Optional testing may be conducted on heat pump-type water heaters to determine E_X. If optional testing is performed, conduct the additional 24-hour simulated use test(s) at one or multiple of the test conditions specified in section 2.8 of this appendix. Prior to conducting a 24-hour simulated use test at an optional condition, confirm the air and water conditions specified in section 2.8 are met and re-set the outlet discharge temperature in accordance with section 5.2.2 of this appendix. Perform the optional 24-hour simulated use test(s) in accordance with section 5.4 of this appendix using the same draw pattern used for the determination of UEF.

* * * * *

6.3 * * *

6.3.1.1 *Effective Storage Volume.* The effective storage tank capacity, V_{eff}, is computed as follows:

$$V_{eff} = k_V V_{st}$$

where:

V_{st} = as defined in section 6.3.1 and

k_V = a dimensionless volume scaling factor determined as follows:

If $\overline{T}_{max,1} \leq \overline{T}_{del,2}$, $k_v = 1$; or

if $\overline{T}_{max,1} > \overline{T}_{del,2}$, $k_V = \frac{\rho(T_{max,1}) \times C_p(T_{max,1}) \times (T_{max,1} - 67.5°F)}{\rho(125°F) \times C_p(125°F) \times (125°F - 67.5°F)}$

or $k_V = \frac{\rho(\overline{T}_{max,1}) \times C_p(\overline{T}_{max,1}) \times (\overline{T}_{max,1} - 19.7°C)}{\rho(51.7°C) \times C_p(51.7°C) \times (51.7°C - 19.7°C)}$

where:

$\overline{T}_{max,1}$ = the maximum measured mean tank temperature after cut-out following the first draw of the 24-hour simulated-use test, °F(°C).

$\overline{T}_{del,2}$= the average outlet water temperature during the second draw of the 24-hour simulated-use test, °F(°C).

$\rho(\overline{T}_{max,1})$ = the density of the stored hot water evaluated at the maximum measured mean tank temperature after cut-out following the first draw of the 24-hour simulated-use test ($\overline{T}_{max,1}$), lb/gal (kg/L).

$C_p(\overline{T}_{max,1})$ = the specific heat of the stored hot water, evaluated at $\overline{T}_{max,1}$, Btu/(lb·°F) (kJ/(kg·°C)).

ρ(125 °F) = the density of the stored hot water at 125 °F, lb/gal (kg/L).

C_p(125 °F) = the specific heat of the stored hot water at 125 °F, Btu/(lb·°F) (kJ/(kg·°C)).

125 °F (51.7 °C) = the nominal maximum mean tank temperature for a storage tank that does not utilize a mixing valve to achieve a 125 °F delivery temperature.

67.5 °F (19.7 °C) = the nominal average ambient air temperature.

* * * * *

6.3.9 *Estimated Mean Tank Temperature for Water Heaters with Rated Storage Volumes Greater Than or Equal to 2 Gallons.* If testing is conducted in accordance with section 5.4.2.2 of this appendix, calculate the mean tank temperature immediately prior to the internal tank temperature determination draw using the following equation:

$$\overline{T}_{st} = T_p - \frac{v_{out,p}}{V_{st}} \times \tau_p(\overline{T}_{in,p} - \overline{T}_{out,p})$$

Where:

$\overline{T}_{st}$ = the estimated average internal storage tank temperature, °F (°C)

T_p = the average of the inlet and the outlet water temperatures at the end of the period defined by τ_p, °F (°C).

$v_{out,p}$ = the average flow rate during the period, gal/min (L/min).

V_{st} = the rated storage volume of the water heater, gal (L).

τ_p = the number of minutes in the duration of the period, determined by the length of time taken for the outlet water temperature to be within 2 °F of the inlet water temperature for 15 consecutive seconds and including the 15-second stabilization period.

$\overline{T}_{in,p}$ = the average of the inlet water temperatures during the period, °F (°C).

$\overline{T}_{out,p}$ = the average of the outlet water temperatures during the period, °F (°C).

* * * * *

6.5 *Energy Efficiency at Optional Test Conditions.* If testing is conducted at optional test conditions in accordance with section 5.6 of this appendix, calculate the energy efficiency at the test condition, E_X, using the formulas section 6.3 or 6.4 of this appendix (as applicable), except substituting the applicable ambient temperature and supply water temperature used for testing (as specified in section 2.8 of this appendix) for the nominal ambient temperature and supply water temperature conditions used in the equations for determining UEF (*i.e.*, 67.5 °F and 58 °F).

[FR Doc. 2022-14687 Filed: 7/13/2022 8:45 am; Publication Date: 7/14/2022]